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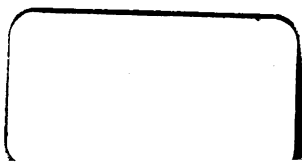
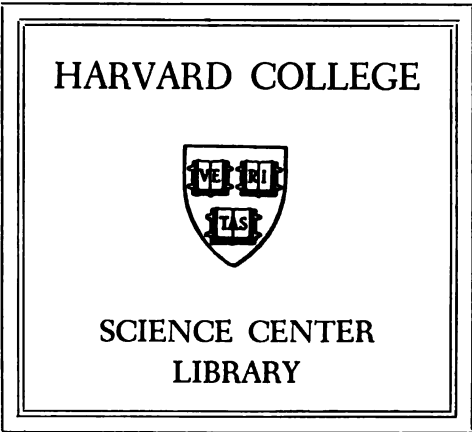
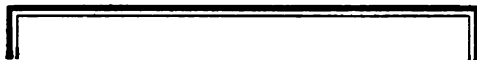
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The Metric *versus* the English System of Weights and Measures

Research Report Number 42
October, 1921

National Industrial Conference Board

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**THE METRIC *VERSUS*
THE ENGLISH SYSTEM
OF WEIGHTS AND MEASURES**

**RESEARCH REPORT NUMBER 42
OCTOBER, 1921**

National Industrial Conference Board

**THE CENTURY CO.
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Foreword

The National Industrial Conference Board presents herewith a report on "The Metric *versus* the English System of Weights and Measures." The report deals with a question of vital and timely importance, not only to the industrialist but to every citizen of the United States. Specifically the question is: "Shall the Metric System Be Substituted by Compulsion for the English System in This Country?" Agitation toward this end has been carried on during many years, and bills for the compulsory adoption of the metric system have from time to time been introduced in Congress. Bills of that nature are now before the House and Senate.

Because of the importance and far-reaching economic bearings of the subject, the Conference Board has prepared this report in order that American industry might be aided by a clear presentation of facts and arguments in determining what its attitude should be towards the proposed change in systems.

The report is presented in three parts. The first deals with the history and present national status of the English, metric and other systems of weights and measures. The second analyzes the application of the English and metric systems to various specialized fields, such as science, engineering, manufacturing and trade. The third sets forth in a judicial spirit, without taking a position either one way or the other, the arguments advanced by advocates of the metric and the English systems respectively, for and against the compulsory adoption of the metric system by the United States.

The Board was fortunate in being guided in its work by an able Advisory Committee composed of the following men of broad business experience and scientific attainment:

E. M. HERR, *Chairman*,
President, Westinghouse Electric and Manufacturing
Company,
East Pittsburgh, Pennsylvania.

FRED J. MILLER,
Past President, American Society of Mechanical
Engineers,
New York, New York.

HENRY D. SHARPE,
Treasurer, Brown and Sharpe Manufacturing Com-
pany,
Providence, Rhode Island.

HENRY R. TOWNE,
Chairman of the Board of Directors,
Yale and Towne Manufacturing Company,
New York, New York.

FRANK O. WELLS,
Formerly President, Greenfield Tap and Die Company,
Greenfield, Massachusetts.

Mr. Joseph Mayer of the Board's Research Staff has acted as Secretary of the Committee, and under his immediate direction the investigation was organized and outlined, the material co-ordinated, and the report prepared.

The members of the Advisory Committee approached the subject from different points of view and with differing sympathies in respect to the issues involved, and have been of valuable service in keeping the work properly balanced. It is a gratification to the Board, and of especial interest to all users of this report, to know that the Advisory Committee fully approves it as presenting an accurate and comprehensive source of information on an important but little understood subject and an impartial synopsis of arguments both for and against the proposal that the metric system be substituted for the existing system of weights and measures in the United States.

CONTENTS

PART I

History and Present National Status of Systems of Weights and Measures

CHAPTER	PAGE
I ORIGIN OF ENGLISH AND OTHER NATURAL SYSTEMS	1
Primitive Systems	3
Development of the English System	4
Comparison of Linear Units of English and other Natural Systems	6
Essential Characteristics and Common Units of the English System	6
II ORIGIN AND SPREAD OF THE METRIC SYSTEM...	9
Early Proposals in France	9
Determination and Construction of the Metric Units	10
Establishment of the System in France	11
Spread to other Countries	12
Essential Characteristics and Common Units of the Metric System	13
III PRESENT NATIONAL STATUS OF ENGLISH AND METRIC SYSTEMS	15
Sources of Material	15
Classification of Countries on Basis of Extent of Use	16
Present National Status by Countries	18
(a) Countries in which Metric System Pre- dominates	18
(b) Countries in which English System Pre- dominates	27
(c) Other Countries	29
Experience in Making Change to Metric System	33

CONTENTS—*Continued*

CHAPTER	PAGE
IV WEIGHTS AND MEASURES IN THE UNITED STATES	36
Early Proposals Regarding Uniformity	36
Influence of Developments in France and Great Britain	37
English System Unified and Standardized	38
Later Metric Developments	40
Present Situation	42

PART II

Use of Metric and English Systems in Special Fields

V IMPORTANCE OF WEIGHTS AND MEASURES IN VARIOUS FIELDS	47
Factors Affecting Use	47
Influence of National Laws	47
Industrial Reasons for Persistence of Old Customs	48
Feasibility of Changing Weights and Measures in Special Fields.....	50
Major Industries of the United States	52
VI SCIENCE AND ENGINEERING	55
Analysis of Fields	55
Science	55
Chemistry	56
Medicine and Pharmacy	56
Industries Using Minute Measurements...	58
Engineering	61
Electrical Engineering	61
Mechanical Engineering	62
Civil Engineering—Land Measurements..	63
Relation to Question of Change	64
VII AGRICULTURE, MINING, TRANSPORTATION, AND TRADE	66
Analysis of Fields	67
Agriculture	67
Mining	70

CONTENTS—*Continued*

CHAPTER	PAGE
VII <i>Continued</i>	
Transportation—Land and Water	71
Trade—Wholesale and Retail	74
Relation to Question of Change	75
The Traveling and Buying Public	76
VIII MANUFACTURING	78
Analysis of Fields	78
Textiles	80
Metal Products	83
Food Products	87
Lumber	88
Paper and Printing	90
Chemical and Allied Industries	91
Leather Products	93
Automobiles	94
Rubber	95
Miscellaneous Industries	97
Relation to Question of Change in the United States	97
Peculiarities of Manufacturing Field	98
Comparison of Manufacturing in the United States and Elsewhere.....	99
Summary	100
IX FOREIGN TRADE	102
Analysis of World Trade	102
Trade Between English, Metric and Other Countries	106
Trade of the United States and Great Britain with Latin America	106
Trade of the United States and Great Britain with Metric Europe	107
Trade Between English and Other Countries	108
Summary	108
Relative Importance of Various Products in Trade of English with Metric Countries..	109
Relation to Question of Change in the United States	110
Exports of the United States.....	110
X SUMMARY OF SITUATION REGARDING THE USE OF METRIC AND ENGLISH SYSTEMS IN SPECIAL FIELDS	114

CONTENTS—*Continued*

PART III

Arguments For and Against the Substitution of the Metric for the English System in the United States

CHAPTER	PAGE
XI INTRINSIC MERITS OF THE METRIC AND ENGLISH SYSTEMS	123
Fundamental Units	123
Multiplication and Division of Units	127
Number and Names of Units	133
Comprehensibility of Systems	135
Convenience, Adaptability and Comprehensive- ness of Systems	137
XII ADVANTAGES AND USE OF METRIC AS COMPARED WITH ENGLISH SYSTEM IN SPECIAL FIELDS	141
Advantages and Use in Calculations, Educa- tional Work, Technical Literature, etc.....	141
Value and Use in Scientific Pursuits	144
Application and Use in Engineering Activities..	146
Advantages and Use in Agriculture, Mining, and Transportation	148
Advantages and Use in Manufacturing	150
Advantages in Domestic Trade	154
Advantages in Foreign Trade	155
XIII PRACTICABILITY OF MAKING A CHANGE TO THE METRIC SYSTEM IN THE UNITED STATES...	161
General Difficulties and Experience of other Countries	161
Effect Upon Established Mechanical Standards	173
Cost of a Change	180
XIV EXTENT AND CHARACTER OF DEMAND FOR A CHANGE TO THE METRIC SYSTEM IN THE UNITED STATES	189
XV COMPARISON OF METRIC AND ENGLISH AS UNIVERSAL SYSTEMS	199
Comparative Extent of Use of Systems	200

CONTENTS—*Continued*

CHAPTER	PAGE
XV <i>Continued</i>	
Justifiability of Extension to all Fields	204
Chances of Adopting the Metric System in Great Britain and the United States	207
XVI SUMMARY OF METRIC CONTENTIONS AND ENG- LISH ANSWERS	212
APPENDIX	217
BIBLIOGRAPHY	252
INDEX	255

LIST OF TABLES AND DIAGRAMS

TABLES

	PAGE
TABLE I: Major Occupations and Industries of the United States	53
TABLE II: Manufacturing: Summary by General Groups, 1914	79
TABLE III: Distribution of World Trade According to Use of Metric, English and Other Systems, 1919	103
TABLE IV: Distribution of Exports of the United States According to Groups of Countries Using Various Systems of Weights and Measures, 1919	113
TABLE V: Present National Status of Metric, English and other Systems of Weights and Measures	218
TABLE VI: Imports into Latin-American Countries and European Metric Countries and Per Cent Imported from United States and United Kingdom, 1913, 1918	230
TABLE VII: Exports and Imports of the Three Groups by Countries; and Exports of the United States to Each Country, and Per Cent such Exports are of the Total Imports of Each Country, 1919	246
TABLE VIII: Imports and Exports of Japan and China, 1913 and 1918	251

DIAGRAMS

DIAGRAM I: Units of Linear Measure Corresponding to the English Foot, Showing Length in Inches and Subdivision Used	7
DIAGRAM II: Distribution of World Population on Basis of Systems of Weights and Measures, 1920	19

	PAGE
DIAGRAM III: Distribution of World Export Trade According to Countries Using Various Systems of Weights and Measures, 1919....	105
DIAGRAM IV: Distribution of Exports of United States According to Groups of Countries Using Various Systems of Weights and Measures, 1919	112
DIAGRAM V: Distribution of Productive Population in Special Fields of Activity in the United States	119

The Metric *versus* the English System of Weights and Measures

PART I

History and Present National Status of Systems of Weights and Measures

CHAPTER I

ORIGIN OF ENGLISH AND OTHER NATURAL SYSTEMS¹

Standards of weight and measure have been recognized since very early times as essential to the development of the commerce, industry, and social life of nations. The rough natural units of primitive man were sufficient only so long as he lived largely to himself and had comparatively little commercial contact with his fellow men. With the progress of civilization came the need of uniformity in the common units used. In time there came also the need of subdivision, extension and coördination of the fundamental units, and the result was the development of systems of weights and measures. Any uniformity thus obtained was naturally first local and confined to small communities or areas. As a tribe or people became better known, however, certain of the units of its system were carried to other communities and districts, and as tribes and cities developed into nations, these primitive ethnic systems, through mandates of rulers and otherwise, became national in scope. Through trade intercourse between peoples of different nationalities and through conquest, some systems took on an international character and in certain instances were adopted either intact or in modified form in countries distant from the place of origin. More recently nations have altered or further systematized their weights and measures by legislation in order to bring

¹ The comprehensive survey of weights and measures made by Hallock, W., and Wade, H. T., in their volume, "Outlines of the Evolution of Weights and Measures and the Metric System," 1906, has been used to a considerable extent as a source for the historical facts presented in chaps. 1, 2 and 4.

them into internal uniformity or into conformity with those of other countries.

The earliest definite systems of weights and measures of which we have knowledge were those of the ancient Eastern kingdoms, and because of certain resemblances to such modern systems as the English or Spanish, authorities on the subject declare that, with the exception of the metric system—of comparatively recent origin—all other systems have descended from them. Whether this is literally true or not, it is a fact that all natural systems of weights and measures in existence today have many characteristics in common and several resemble one another so closely as to suggest a common origin.

The metric system may be broadly distinguished from these other systems by the fact that it is modern, nonracial, impersonal and somewhat artificial in nature, being related only to the length of a certain selected terrestrial meridian, while the other systems are of ancient development, ethnic or popular in character, and natural in origin, being generally derived from lengths of portions of the human body, from dimensions or weights of familiar natural objects or being in other ways connected with common experience.

The English system is the outstanding example of the popular or ethnic systems of ancient origin which are in use at the present time. It is the most important of them because it is practically the sole system of the English-speaking peoples of the world and because the bulk of the world's commerce is carried on in this system.¹ The metric system has been adopted as the official standard in most countries of the world outside of the United States, Russia, the British Empire, and their dependencies and dominions, although many old systems are still in use in so-called metric countries. The only real competitor of the metric system, however, is the English, and the general similarity between the English and other natural or popular systems makes it important that there be an understanding of the origins of natural systems and their relation to human habits and psychology.

It should be noted that units of weight and capacity enter but little into the present controversy between the English and metric systems. In all systems these units are secondary in importance to units of length. They are, in the first place, frequently dependent upon or derived from the linear units. More important, however, is the fact that a change in the units of weight and capacity affects in the main only the scales and containers used. The material weighed or measured as to capacity, such as a ton of coal or a quart of milk, is not intimately involved with the weight or measure, and in any case is comparatively soon used up. Machinery, buildings, various kinds of permanent equipment and land

¹ See p. 103.

areas are, on the other hand, closely bound up with the units of length that went into their construction or definition and stand for a relatively long period as embodiments of these units. The measures of length, therefore, take on a fundamental significance in all discussions relating to weights and measures, and it is to linear measures that chief attention is devoted in the following pages.¹

PRIMITIVE SYSTEMS²

Measures of length among ancient peoples were of several distinct classes: the shorter ones used for building and manufacturing purposes; those used in measuring shorter distances; measures of long distance; measures of land area.

There is evidence that from very early times the longer measures of length were based on the geographical mile³ (the estimated length of one minute of arc of a great circle of the earth), indicating that ancient peoples used the sexagesimal division of the circle and had considerable astronomical knowledge. Such distances as that covered in a day's march came to be used for longer distance measures also.

It is the short units, however, such as the inch and the foot, which are of chief importance in all natural systems. As industry developed, these shorter units were subdivided to serve the purposes of more minute measurements, and at remote periods and in various ways among different peoples the shorter and the longer units were assimilated into a continuous scale.⁴

The primitive systems developed in Egypt, Babylonia, China, Rome, and Greece were all based, with respect to their short units of length, on lengths of portions of the human body or upon the sizes of familiar natural objects such as seeds. Most commonly, in measuring small distances the primitive man would take the length of his foot or the breadth of his hand as the unit. It is natural that this should result in considerable diversity, since individuals differ in physical structure, although in a given race there would exist a similarity not to be found between races. How the length of the foot as the unit of measure differs in various countries is shown in graphic form later.⁵ The most common of

¹ It must be borne in mind, however, that measures of weight and capacity have come to be used in modern times with those of length in compound units, such as "pounds per square inch," "bushels per acre," and in such connections as textile yarn numbers which indicate sizes through the use of the "yard-pound."

² Regarding the origin and relation of ancient measures see discussion and references in Hallock and Wade, *op. cit.*; also Watson, reference mentioned below.

³ Identical with the modern English nautical mile.

⁴ Watson, Sir Charles M., "The Origin of English Measures of Length." *Journal of the Royal Society of Arts*, reprinted in *American Gas Light Journal*, Feb. 21, 1916, pp. 115-117.

⁵ See diagram, p. 7.

the measures based upon lengths of portions of the human body were the digit or finger breadth; the length of the first joint of the forefinger, about one inch; the palm, or the width across the open hand at the base of the fingers; the hand, or the width across the full palm inclusive of the thumb, equal to about four inches; the foot, twelve inches; the cubit, equal to the length of the arm from the elbow to the end of the middle finger, about eighteen inches; and the fathom, equal to the length of the arms outstretched, about six feet.

The manner in which the various primitive units were subdivided reflects in general the systems of notation used by the people. In Egypt and also in China and Japan the linear units were subdivided decimally, that is, into tenths. Among the Babylonians and Assyrians the basis of division was sexagesimal, that is, into sixtieths, as in our modern notation of time. The Romans divided their units duodecimally, that is, into twelfths, and this division applied to the Roman measure of weight and capacity as well as to the linear measure. The Hindus appear to have used binary subdivision, that is, repeated division into halves, making quarters, eighths, sixteenths, and so on, which method of subdivision was also followed by the Germanic and Teutonic peoples and by the Arabs despite the accompanying use of the decimal system of notation by the latter. Since the Roman and Germanic peoples influenced Anglo-Saxon development considerably, one would expect to find both duodecimal and binary subdivision employed in the English system. This is a fact, although it is true also that the decimal system of subdivision is coming into increasing use in English speaking countries, as is evidenced by the system of coinage in the United States and by the extensive decimalization of the inch and foot in modern industry and engineering.

DEVELOPMENT OF THE ENGLISH SYSTEM

English measures and weights are no haphazard modern invention, but have come down to us from prehistoric times. How the measures originally came to England is not certain, but they were in use before the Roman invasion, having possibly been introduced by the Phoenician traders and afterwards modified by the Romans, the Saxons, the Scandinavians and the Normans, each of whom had measures based on the old units.¹

The systems of weights and measures which were probably influential in forming the English are the Greek and the . . . The Greek foot or *pous* was equivalent to 12.08 inches and the Roman foot to 11.60 inches.² One authority says regarding

¹ Watson, *op. cit.*, pp. 116, 117.

² John Greaves (London, 1737), who investigated Roman weights and in Rome, gives the lengths as stated.

Roman foot that "it has not only extended throughout Europe as a fundamental unit, but in some form has survived almost everywhere until supplanted by the meter. . . ." Various values were ascribed to the Roman foot in different sections, but its supremacy "as the unit of length was maintained in Europe until the nineteenth century."¹ The English land mile is also of Roman origin and corresponds to the Roman *millia passuum*, while the English sea mile is exactly the same as the geographical mile of the Babylonian system, and its tenth part, the cable length, is identical with the *stadium* of the Greeks.

The Anglo-Saxons early endeavored to secure uniformity by enacting good laws, and in this they were so successful that they were enabled to maintain their weights and measures in their integrity despite the Norman conquest.² The most important early English legislation was contained in the Magna Charta (1215) and laid stress upon the principle of uniformity, by providing that there should be "throughout the realm one measure of wine, one of ale, and one of corn . . . and that it should be of weights as of measures. . . ."³

Unlike the measures of weight and capacity, there have been few changes in those of length from the times of the Saxons. In fact, the Anglo-Saxon measures of length down to the present have remained on the same basis as is given in the statute of Edward II (1324) where there is a statement in statutory form of what has since become the well-known rule that "three barley corns round and dry make an inch, twelve inches a foot, three feet a yard, five and one half yards a perch, and forty perches in length and four in breadth an acre."⁴

Several capacity standards constructed in 1495 still survive, namely, a corn gallon and a corn bushel known as the Winchester bushel.⁵ These were employed in Great Britain until superseded by the present imperial gallon and bushel as the result of a royal decree in 1824, but the old Winchester bushel still survives today as the standard bushel of the United States. Likewise an ale gallon and a wine gallon recognized in Great Britain until 1824 remain as legal measures in the United States. While this discrepancy appears in measures of capacity, the important linear measures in both Great Britain and the United States have been thoroughly unified and standardized. Today the inch and foot have become almost inextricably into the manufacturing and commercial activities of English speaking nations.

¹Hallock and Wade. "Outlines of the Evolution of Weights and Measures and Metric System," 1906, p. 26.

²*Ibid.*, pp. 30, 31.

³*Ibid.*, p. 32.

⁴*Ibid.*, p. 36.

⁵*Ibid.*, p. 35.

COMPARISON OF LINEAR UNITS OF ENGLISH AND OTHER NATURAL SYSTEMS

Diagram I shows the relation of the units of length of the natural systems of various important countries to the unit of length of the English system. The first column gives the name of the country; the second, the name of the unit used in that country corresponding to the English foot; the third, the length of this unit in inches; and the fourth, the method of subdivision employed.

Diagram I evidences the essential similarity between natural systems of linear measure. The average length in inches of the unit corresponding to the English foot is 12.02 inches and the average of the unit corresponding to the inch is 1.02 inches. Thirty-three of the thirty-five countries covered employ in their natural systems the duodecimal method of subdividing the foot into the smaller units corresponding to the inch. The remaining two, Japan and China, use decimal divisions. A number of these countries today employ the metric system, either in place of their natural systems or along with them.¹

ESSENTIAL CHARACTERISTICS AND COMMON UNITS OF THE ENGLISH SYSTEM

The fundamental units of length in the English system are the inch and the foot. These units have not been mechanically devised but are of ancient origin and are found with slight variations among practically all peoples. They are, in the main, related to lengths of portions of the human body, affording a rough natural standard of comparison and measurement always available, and have thus become deeply rooted in common habits and customs. The length of the human foot serves as a convenient approximation to the linear unit of twelve inches, and the length of the first joint of the forefinger represents the inch. In a similar way handy weights and ready measures for capacity have been developed in the English system.

Other units of length, such as the digit, the hand, the palm, the cubit and the fathom have likewise arisen out of primitive customs, but only those have been retained in common use which have survived the test of age-old experience and have been found peculiarly adapted to various needs. The digit or finger breadth appears to have been found too small a unit for most purposes, and the palm or hand too large, while the inch seems to have been found admirably adapted for the most common of measurements and the

¹ For detailed information respecting the linear and other measures and weights of foreign countries see Tate's "Modern Cambist," 25th Edition.

DIAGRAM I.
UNITS OF LINEAR MEASURE CORRESPONDING TO
THE ENGLISH FOOT, SHOWING LENGTH IN INCHES AND
SUBDIVISION USED.*

(National Industrial Conference Board)

Country	Name of Unit	Length in Inches	How Subdivided
China	Ch'ih	14.10	10ths
Turkey	½ Pik	13.5	12ths
Portugal	Pe	12.96	12ths
France	Pied	12.79	12ths
Austria	Fuss	12.44	12ths
Germany	Fuss	12.36	12ths
Norway	Fod	12.36	12ths
Denmark	Fod	12.36	12ths
Babylonia		12.24	12ths
Greece	Pous	12.08	12ths
Canada	Foot	12.00	12ths
Great Britain	Foot	12.00	12ths
Russia	Foute	12.00	12ths
United States	Foot	12.00	12ths
Japan	Shaku	11.93	10ths
Switzerland	Fuss	11.89	12ths
Belgium	Pied	11.81	12ths
Sweden	Dot	11.69	12ths
Roman	Pes	11.60	12ths
Holland	Voet	11.15	12ths
Philippines	Pie	11.13	12ths
Spain	Pie	11.13	12ths
Latin America	Pie	†11.05	12ths
Siam	Kup	10.00	12ths

(English) Foot

*There appears to be a slight difference of opinion among authorities as to the exact length of some of these old units, but the figures given here represents those most generally accepted.

†This figure represent the average length of the "Pie" for twelve Latin-American countries for which definite data were obtainable.

foot for such uses as surveying. The yard has been retained as a measure for cloth, and the acre for land.

The English system decimalizes its units wherever expedient, but for most purposes uses the method of binary subdivision, or repeated splitting into halves. The relationship between the inch and foot is duodecimal. In the mechanical trades it has been found convenient to decimalize the inch, and in civil engineering practice the foot is decimalized. The binary method of division is particularly adapted to every-day affairs and to mental operations as against written calculations.¹ The English system, therefore, employs decimal subdivisions where expedient and also employs binary divisions where these seem to be most convenient. It is considered very comprehensive in filling the needs to which a system of weights and measures should be put, both with reference to its divisibility and also with reference to the convenience and adaptability of the units to various special fields of industry.

Having such a close connection with every-day experience, the names and sizes of the various units of the English system are easily comprehended and readily retained. The names of measures of weight, length, and capacity are all monosyllabic, with three exceptions in which two syllables occur. The common units in use and the relationship between them are indicated in the following list:

Length—

Inch		
Foot	=	12 inches
Yard	=	3 feet
Mile	=	5,280 feet
Acre	=	4,840 square yards

Capacity—

Pint		
Quart	=	2 pints
Gallon	=	4 quarts
Peck	=	8 quarts
Bushel	=	4 pecks

Weight—

Ounce		
Pound	=	16 ounces
Ton (Short)	=	2,000 pounds

There are other units in use, but those listed are probably the most common.

¹ The natural convenience of binary division and multiplication of units is attested by the fact, noted later (see p. 140) that even where the metric system is used, despite its decimal structure binary divisions are in common practice.

CHAPTER II

ORIGIN AND SPREAD OF THE METRIC SYSTEM

A discussion of the history of the metric system naturally centers about its rise and development in France, the country where it originated in the latter part of the eighteenth century.

Preceding its advent various systems of weights and measures had been in use in France, some of them dating back to the time of Charlemagne (768 to 814). The unit of length in Charlemagne's time was probably derived from the Roman foot. It was called the "*piéd de Roi*" (the royal foot) and was equivalent, as has been noted, to 12.79 English inches. Other units were in use in various localities, but it is of interest to note that the linear measures were all based on units corresponding to the English foot and were divided into twelfths. The diversity of local systems in use resulted in considerable confusion, so that toward the end of the seventeenth century proposals looking toward unification came to the attention of the Government.

EARLY PROPOSALS IN FRANCE

In 1670 Gabriel Mouton, Vicar of Saint Paul's Church, Lyons, proposed a comprehensive decimal system based on the length of the arc subtended by an angle of one minute of a great circle of the earth. One of the dimensions of this system, the "geometric foot," was further defined by Mouton as corresponding to the length of a pendulum making 3959.2 vibrations in a half hour at Lyons. This proposal is of interest because of the use of the great circle of the earth as a basis for measures of length by the ancients and because it was the great circle which, over a century later, was chosen as the basis in the metric system.

At various times during the seventeenth and eighteenth centuries suggestions were made looking toward the decimalization of the units of weight and measure and the adoption of the second's pendulum as a unit of length. M. Prieur Du Vernois¹ proposed that one third of this length be designated the "foot," and that this be divided into ten "inches" of ten "lines" each. Units of capa-

¹ M. Prieur Du Vernois, as an officer of engineers, presented to the National Assembly in 1790 a "Memoire" on the standardization of weights and measures. The adoption of the metric system was partly due to his efforts.

city were to be measured by cubes based upon the linear units. The unit of weight was to be a "pound," corresponding to the weight of a cubic "foot" of distilled water at some designated temperature.

These and other schemes were proposed from time to time to simplify and promote uniformity in weights and measures throughout France.

DETERMINATION AND CONSTRUCTION OF THE METRIC UNITS

Having finally made the decision that a system of weights and measures different from any of those then in use was necessary in the interest of simplicity and uniformity, the French Government in 1790 appointed a committee of the Academy of Science to undertake the making of a new system based upon some fundamental scientific measure. Three measures were proposed, namely: the length of a second's pendulum, the length of a quadrant of the terrestrial equator, and the length of a quadrant of a terrestrial meridian. The committee reported in favor of the terrestrial meridian measure and decided to use the one ten-millionth part of a quadrant of the meridian passing through Dunkirk and Barcelona as the standard unit of linear measure under the new system. To this unit of length the designation "meter" was assigned.

A provisional meter was derived by calculation and fixed at a length which was 0.35 millimeters longer than the length later arrived at by more careful measurement. The relations between the measures of length, weight, and capacity were also agreed upon and names for the various units were devised. Two systems of nomenclature were proposed. One was called "methodical" and used Latin prefixes, and the other one proposed simple, monosyllabic names which it was held the people would more readily adopt. The Latin prefixes were decided upon, and on August 1, 1793 a decree was issued adopting the new system and outlining the means for establishing it. By further legislation of April 7, 1795, the various units were precisely defined and provision was made for the construction of standards.

The determination of the distance from Dunkirk to Barcelona was originally begun in 1792. After seven years of difficulty which was augmented by the political upheaval then in progress, the meridional quadrant was finally determined as equivalent to 32,808,992 English feet. From this measurement the new standard kilogram, based on the unit of length, was constructed, and on December 10, 1799, the provisional meter was abolished, the new meter and kilogram adopted by statute, and the new standards formally deposited in the archives at Paris. These standards for the meter and kilogram are the ones in use today, although later researches have shown that a slight discrepancy exists between

the meter and one ten millionth part of the meridional quadrant and between the kilogram and the weight of a cubic decimeter of water at maximum density, to which the kilogram was intended to be equivalent. It has been shown, moreover, that the meridional great circle is not constant in length.¹

ESTABLISHMENT OF THE SYSTEM IN FRANCE

From 1799 to 1840 the work of putting the metric system into general effect in France proceeded very slowly. Changes in political conditions, the unfamiliar nomenclature of the new system, the lack of copies of the standards (which the Government had not distributed as it promised), the early abolition of the Office of Weights and Measures, the lack of public scales accommodated to the new system, and the many abuses and frauds arising from these and other causes—all served considerably to hamper progress.² So many objections arose from the people that the Government was forced to take cognizance of the situation. A decree was issued November 4, 1800, declaring anew "that the decimal system of weights and measures would definitely be put into execution for the entire republic beginning September 23, 1801." In February, 1812, however, Napoleon issued another decree, establishing as optional a system of measurements based upon the metric system and using such divisions and multiples as would make the new units approximately those of the old system. To the units of this newest system the old terms were applied.

This decree of Napoleon remained in force until 1837. The twenty-five years between 1812 and 1837 were marked with such confusion and fraud, due to the use of two comparatively new systems and the natural reversion to the old system, that in 1837 the question of revising legislation pertaining to weights and measures came up in the House of Deputies and resulted in the repeal of the decree of 1812. A new decree was issued declaring all weights and measures other than the metric units forbidden after January 1, 1840. It was not until after this compulsory

¹ About the middle of the nineteenth century, Sir John Herschel, an eminent English scientist and astronomer, estimated the length of the meridional quadrant to be 32,813,000 English feet, which would make the meter $1/208$ of an inch shorter than the one ten-millionth part of the meridional quadrant.

It has not been possible in this report to enter into a full discussion of the technical and international aspects of the development of metric standards. It should be mentioned, however, that since 1795 the determination and elaboration of metric units and the construction of standards and prototypes, and the task of fostering the development of the metric system has been in the hands of an international body comprising a varying number of countries—The International Commission on Weights and Measures—under which an international bureau of weights and measures has been established and which was largely responsible for the metric treaty of 1875 mentioned on page 13.

For a detailed description of the work of French scientists in deriving the metric units, in constructing standards and copies of standards, and for the history of the International Commission on Weights and Measures, see Gould, B. A., "Address on the Metric System of Weights and Measures," before the Commercial Club of Boston, February 18, 1888, page 4; also Hallock and Wade, *op. cit.*, p. 62 ff.

² Hallock and Wade, *op. cit.*, p. 64.

measure of 1840, therefore, that real progress in the adoption of the metric system throughout France was secured, though difficulties in its enforcement have been encountered down to the present day.¹

SPREAD TO OTHER COUNTRIES

The spread of the metric system must naturally be traced by the dates at which the system was first introduced into the various countries, which dates usually mark the time at which the system was made optional or permissive. Optional use did not carry with it the abolition or suppression of other systems of weights and measures in use, such suppression not usually being effected unless the metric system was adopted as the sole legal standard of the country and its use thus made compulsory. Practically every country in the world has made the metric system legally permissive. It is permissive in the United States and Great Britain. The compulsory establishment of the system, however, is another matter, which will be dealt with in the following chapter.

The crystallizing of sentiment in favor of the adoption of the metric system in countries other than France probably dates from the London Exposition of 1851, at which time the disparity between various local systems of weights and measures in the products there exhibited was emphasized. The convenience of decimal divisions as applied to money resulted in the Vienna Coin Treaty of January 24, 1857, putting metallic currency upon a decimal basis in the signatory countries, and in a similar action by the so-called Latin Union of 1865, and these international actions probably served also to encourage the adoption of the decimal metric system for weights and measures.

Previous to the London Exposition the metric system had been introduced in 1816 into Belgium, Luxemburg, and the Netherlands, which countries were at that time under the domination of France, and into Greece in 1836. The first extensive spread occurred in 1849 to Spain and in 1852 to Portugal, and in consequence to the Spanish speaking countries of Central and South America, many of which were still dependencies or colonies of Spain and Portugal. In Latin America the metric system was introduced in Chile in 1848; in Cuba and Porto Rico in 1849; in Columbia and Panama in 1853; in Ecuador in 1856; in Venezuela in 1857; in Mexico, Uruguay and Brazil in 1862; in Argentina and Peru in 1863; in San Domingo in 1867; and in Bolivia in 1870. It was at the height of this movement in 1866 that the United States made the metric system permissive by legislative act. Great Britain legalized the metric system in 1864; Canada and India followed in 1871, and Egypt in 1873.

¹ See pp. 167-168.

Other European countries also adopted the metric system about this time. In Italy the dates of introduction varied from 1845 to 1870 in different parts of the country. Germany followed in 1870; Austria, Czecho-Slovakia and Serbia in 1873; Switzerland in 1875; Hungary and Monaco in 1876; Bosnia-Herzegovina in 1878; and Sweden and Norway in 1879.

In 1875 a metric treaty to which 26 countries have since become parties was signed at Paris. With this treaty probably began the spread of the metric system beyond European boundaries farther East, and South into Africa and Turkey. It had been introduced into the Philippines as early as 1849. Roumania adopted the metric system in 1884; Finland and Turkey in 1886; Montenegro and Bulgaria in 1888; Siam in 1889; Japan in 1891; Tunis in 1895; Russia in 1900; the Congo in 1910; Tripoli in 1913; China in 1914; and Latvia and Poland in 1919. During the same period further accessions occurred in Latin America, and in Denmark, which adopted the metric system in 1910. Costa Rica was added to the list in 1885; Salvador in 1886; Nicaragua in 1893; Guatemala in 1894; Honduras in 1897 and Paraguay in 1899. At the present time, exclusive of several small provinces and states, the metric system has been legalized in every well-known country except Australia and New Zealand.

ESSENTIAL CHARACTERISTICS AND COMMON UNITS OF THE METRIC SYSTEM

The fundamental unit of length in the metric system is the meter. This unit was intended to represent an exact portion of a great circle of the earth's circumference passing through the poles. Although a slight error was made in the measurement, copies of the meter have been distributed and made legal in practically every country the world over. The system is so devised as to provide a close interrelation between the units of length, capacity and weight. The liter, which is the basic unit of capacity, is the volume of one-tenth meter cubed. The gram, which is the fundamental unit of mass, is the weight of a volume of pure water at maximum density, equal to one-hundredth of a meter cubed.

With respect to the multiplication and division of units, the metric system is distinctly decimal. By this it is not meant that the meter is any more a decimal unit than is the foot or the inch nor that the units of the English system are not so easily and frequently decimalized where expedient as the metric units, for, as was pointed out, the inch and the foot are being subjected to decimal divisions quite extensively in engineering and related practices. What is meant, however, when it is said that the metric system is distinctly decimal is that this system, generally speaking,

uses decimal notations and no other.¹ The meter is divided into tenths (decimeters), hundredths (centimeters) and thousandths (millimeters), while for more minute measures the millimeter is further divided into hundredths. The larger unit of linear measure is the kilometer, of 1,000 meters. In a similar manner the liter, for capacity measures, is subdivided into deciliters and milliliters, and the larger units are the dekaliter, the hectoliter and the kiloliter. The larger units of weight are the kilogram of 1,000 grams, the quintal² of 100 kilograms, and the ton of 1,000 kilograms. It is this simplicity with respect to the multiplication and division of the units of the metric system, harmonizing as it does with our decimal system of notation, which, generally speaking, makes the system admirably adapted for work in which computations and calculations are extensively used, although today the use of calculating machines and similar devices has in large part removed the burden of computing from the individual to the mechanism.

The names of the units of the metric system indicate the decimal relationship which each smaller or larger unit holds to the fundamental unit. The prefixes "deci," "centi," and "milli" are added to the stem "meter," "liter" and "gram" to indicate, respectively, units 1/10, 1/100, and 1/1000 as large as the basic one. The prefixes "deka," "hecto," "kilo," and "myria" are similarly added to indicate the larger units respectively 10, 100, 1,000, and 10,000 times as large as the meter, liter and gram.

The common units in use and the relationship between them are indicated in the following list:

Length—

Millimeter	=	.001	Meter
Centimeter	=	.01	Meter
Meter			
Kilometer	=	1,000	Meters
Hectare	=	10,000	Square Meters

Capacity—

Liter			
Dekaliter	=	10	Liters
Hectoliter	=	100	Liters
Kiloliter or Stere	=	1,000	Liters

Weight—

Gram			
Kilogram or Kilo	=	1,000	Grams
Tonne	=	1,000,000	Grams

There are other units in use, but those listed are probably the most common.

¹ See, however, p. 139 of present report.

² The metric quintal of 100 kilograms is sometimes confused with the Spanish quintal equivalent to 46 kilograms.

CHAPTER III

PRESENT NATIONAL STATUS OF ENGLISH AND METRIC SYSTEMS

Considerable controversy has arisen as to how widely the metric system is used the world over.¹ As has been pointed out, it is one thing to say that the metric system has been legalized in nearly every country; it is another to assert that it has actually come into general use as a result of compulsory measures or otherwise. It is true that with few exceptions every country of the world has legalized the metric system, but it is likewise true that there are very few countries the world over to which the trade of Great Britain and the United States has not carried the English system of weights and measures to a greater or less extent. Such generalizations are, however, of little value, and in order to afford a correct idea of the present national status of the English and metric systems it is necessary to present an accurate estimate of the extent to which they are actually used in the various countries in which they have been introduced. This estimate is made on the basis of predominant use.²

SOURCES OF MATERIAL

In order to present a comprehensive picture showing those countries which might be considered as falling into the metric group on the basis of predominant use, those which should fall into the English column, and those which could logically be classified in neither way, the National Industrial Conference Board secured information from first-hand authoritative sources. By personal interview and through correspondence, data were collected from foreign consuls in this country and access was obtained to the excellent and comprehensive survey made during 1919 and 1920 by the United States Government through its own consuls stationed in foreign countries.³

¹ See Halsey, F. A., and Dale, S. "The Metric Fallacy," new edition, p. 130; *ibid.*, old edition, pp. 14, 19, 22, 23, 55, 86; also American Society of Mechanical Engineers. Transactions, Vol. XXIV, pp. 420, 470, 471, 493, 502, 503, 519, 524 and 528. See also Chap. 15 of present report.

² By "predominant use" it is meant simply to indicate in a general way which system of weights and measures is the prevailing system of a country, i.e., the one most generally or commonly used, in spite of the fact that other units of weight and measure are also used to some extent.

³ United States Department of Commerce. Unpublished Consular Reports on the Metric System of Weights and Measures in Foreign Countries; also published consular letters in *Commerce Reports*, 1920-1921.

Authoritative data as to the national status of the English, metric and other systems of weights and measures the world over were thus secured and this information was then checked with other sources.¹ The results are summarized in the following pages and in Appendix table V.

CLASSIFICATION OF COUNTRIES ON BASIS OF EXTENT OF USE

In attempting a broad classification of the countries of the world on the basis of the predominant use of the metric and English systems, important questions were asked with regard to each of the countries examined, as, for example, the following:

- (1) Had the metric system been made compulsory, and whether for all uses, or for limited uses only, as for official government use?
- (2) Was there any determining influence, such as a close political connection or an almost exclusive trade relation, which had extended the general use of the English system to countries outside of the United States and Great Britain and their dominions or dependencies?

Through answers to these and similar questions and an examination of the data collected, countries were classified either as English or metric, or where the evidence indicated that a country could not be said to be using either the metric or the English system predominantly it was placed in a third group called "Other Countries." In the following section, of which the paragraphs below are a summary, is given in detail the present status of the various countries of the world under this three-fold classification.

Russia, the United States, Great Britain, and certain of their dependencies, dominions, or protectorates, namely, Canada, New Zealand, South Africa, British Guiana, Australia, Liberia, the Straits Settlements, Porto Rico and San Domingo, use the English system as the predominant system of weights and measures.² The total population in these twelve countries is about 343,557,000. Many other countries use the English system to a limited degree in some special field.

Besides having been legalized almost everywhere, the metric system has been made compulsory in a number of countries. The extent of its compulsory adoption ranges, however, all the way

¹ Guillaume, Ch-Ed., Bureau of International Weights and Measures, "Le Recent Progrès du Systeme Metrique," 1913; "Statesman's Yearbook," 1920; Hallock and Wade, "Outline of the Evolution of Weights and Measures and the Metric System," 1906; Tate's "Modern Cambist," 25th Edition; publications and reports of the United States Bureau of Standards; publications and reports of the American Metric Association; publications and reports of the American Society of Mechanical Engineers; publications and reports of the American Institute of Weights and Measures; Colombian Bureau of Information, New York City; Chilean Bureau of Information, New York City.

² The predominant use of the English system in the United States and Great Britain is tantamount to universal use, because no other system preceded the English in these countries, because there were no ancient systems to be suppressed, and because the metric system is employed to a very limited extent.

from compulsory use in a very limited sense only—as in the United States, where it is compulsory in the medical work of the Army and Navy and in the United States Public Health Service—to compulsory use for all purposes and for all the people. Generally speaking, in no country has the metric system come into predominant use unless it has been made compulsory for all uses.¹

In nine countries² the metric system has been made compulsory in official governmental transactions only, and authoritative reports show that in only one of these, Colombia, has its use spread much beyond governmental work. In Colombia the metric system is said to be in general use, but in the remaining eight the old Spanish or other old systems of weights and measures predominate.

In thirty-eight countries³ the metric system has been made compulsory for all uses, and in all of these, excepting Costa Rica, Greece and Salvador, the result has been that in varying degrees in different fields the metric system has in a large measure supplanted the older systems.⁴ In Greece the compulsory law did not go into effect until 1920, so that the results are not yet in evidence; in Costa Rica and in Salvador there appears to have been a laxness in the enforcement of the law. In the remaining thirty-five countries, plus Colombia and the small metric country of Liechtenstein, making a total of thirty-seven in all and comprising a population of 395,521,000, the metric system can be said to have come into predominant use.

In twenty-eight countries,⁵ including Costa Rica, Greece, Salvador and the eight of the nine in which the metric system is used in official governmental transactions only, comprising in all of the twenty-eight a population of 823,690,000, neither the English nor

¹ The metric situation in a country depends not only on the stringency and comprehensiveness of the law but also upon the vigor of the enforcement and the ease or difficulty with which the metric system has been able to displace the older units already established in various fields of industry. In general the enforcement is far more strict in the commercial than in the industrial application. Commercial practice is open to daily observation and experience by every one, while the industrial application affects only those engaged in productive industry.

² Bolivia, Colombia, Ecuador, Egypt, Guatemala, Panama, Peru (extended by municipal decree in Lima and Callao), Siam (public works and railways), Turkey (made compulsory also for cereals and in Constantinople for all uses).

³ Argentina, Austria, Belgium, Brazil, Bulgaria, Chile, Congo, Costa Rica, Czechoslovakia, Denmark, Finland, France, Germany, Greece, Haiti, Hungary, Italy, Jugoslavia (Serbia, Bosnia-Herzegovina), Latvia, Luxemburg, Mexico, Monaco, Montenegro, Netherlands, Nicaragua, Norway, Paraguay, Philippines, Poland, Portugal, Roumania, Salvador, Spain, Sweden, Switzerland, Tunis, Uruguay, Venezuela.

⁴ In these countries the metric system is now in predominant use, but this does not imply exclusive use, since in many metric countries people in the interior, or the ignorant classes, still cling to the older units of weight and measure. Older units are also commonly used in metric countries in special fields such as in textiles, lumbering, navigation, or the machine industry. Part II of this report examines special fields in detail as related to the use of weights and measures.

⁵ In addition to Costa Rica, Greece, Salvador and the eight countries other than Colombia listed in footnote 2 above, the following seventeen are here included: Abyssinia, Afghanistan, Armenia, China, Cuba, Hedjaz, Honduras, India, Japan, Mesopotamia, Morocco, Nepal, Oman, Palestine, Persia, Syria, Tripoli. With regard to Japan see footnote, p. 32, of this report.

the metric system is in predominant use. Of other systems in use in these countries, the Spanish system of weights and measures, closely akin to the English system, is in predominant use in nine countries comprising a population of 18,640,000. In five of the remaining nineteen countries the Turkish system of weights and measures is chiefly used; in the rest various local systems, such as the Japanese, Chinese, Egyptian, Persian, and Indian systems are largely employed.

The distribution of metric, English and other groupings by populations¹ based upon the preceding classification is indicated in the chart on facing page.

PRESENT NATIONAL STATUS BY COUNTRIES

In the following analysis based upon the first-hand sources already spoken of, this three-fold classification is adhered to. The first sub-section lists countries in which the metric system is in predominant use and indicates the present situation with respect to weights and measures in these countries; in the second sub-section are listed the countries in which the English system predominates; and in the third, other countries are given. The arrangement throughout is alphabetical. In the Appendix² will be found a table giving the names of the countries, the population of each, the date the metric system was made optional, the date, if any, at which it was made compulsory, and under "Other Countries" a list of the local systems used. The present section is an elaboration of this table, with an especial view to presenting a clear picture of the status of weights and measures in each of the countries listed.

(a) Countries in which Metric System Predominates

Argentina. Under a law passed in 1863 the metric system was legalized in the Argentine Republic. Considerable difficulty was experienced in the enforcement of this law, so that a second act was passed in 1877, making it compulsory to use the metric system in all contracts and commercial transactions after January 1, 1887. This law also provided for the use of the metric system in all branches of the national and provincial administrations after January 1, 1879.

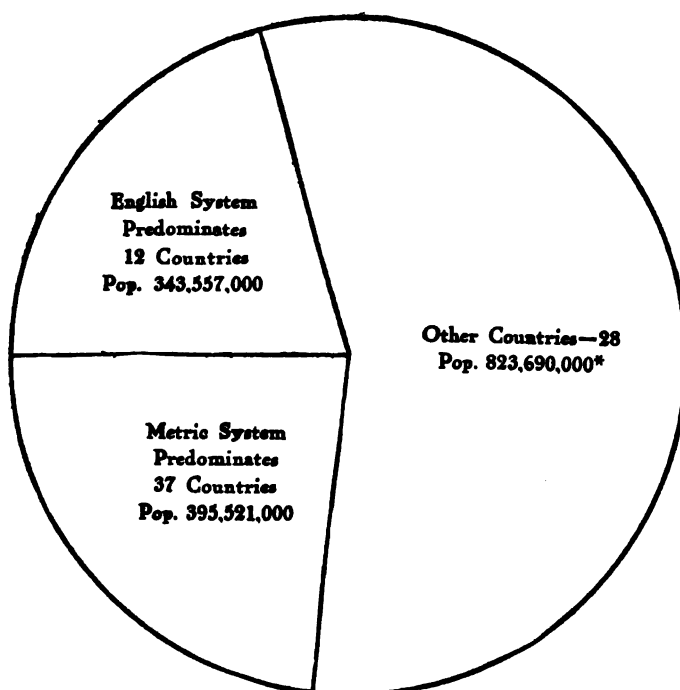
¹ The populations are for the most part taken from the "Statistical Abstract of the United States," 1920, Table 454, pp. 838, 839, pp. 826-7, which gives the figures for 1920 or for the latest available date.

The population figures of the three groups of countries are not to be taken as a full measure of the actual number of people using either the metric or the English system, since the metric system is used to some extent in predominantly English countries and the English to some extent in predominantly metric countries and both systems to a greater or less extent in countries in which neither predominates. The graph serves, however, to present the general situation both as regards the number of countries in the three major groups and the relative sizes of the groups.

² Table V.

DIAGRAM II
DISTRIBUTION OF WORLD POPULATION
ON BASIS OF SYSTEMS OF WEIGHTS
AND MEASURES—1920

(National Industrial Conference Board)



*Includes colonies and dependencies not otherwise classified.

At the present time the metric system is in general use throughout Argentina by the government, in commerce and by the people at large. The English nautical mile and other English terms are often used in navigation and shipping, and some of the old Argentine denominations still survive in the provinces. Land transactions are still carried on in the old Spanish units (square *varas*) although in all such transactions the indication of metric equivalents is required. Foot (*pie*) measures are used to a large extent, although illegally, in lumber transactions, and the bushel (*fanega*) is sometimes used to measure the yield of cultivated land.

Austria. The metric system was adopted in Austria by the law of July 23, 1871, under which its use became obligatory after January 1, 1876. With the exception of the English nautical mile and ship ton, no other units than the metric have been allowed by law since January 1, 1886. Old measures are seldom found at the present time except in navigation and in the machine industry.

Belgium. Due to the fact that the original metric law in Belgium passed in 1820 was not vigorously enforced, the change in weights and measures was gradual. In 1855, however, a more rigorous law established the exclusive use of the French weights and measures and at the present time the metric system is in general, although by no means exclusive, use.

Brazil. Brazil adopted the metric system in 1863, and on January 1, 1864, it became the sole legal standard of the country. It is now used in nearly all official matters and generally by the people at large. The metric system has not, however, succeeded in completely suppressing the old Brazilian system of weights and measures, particularly in the interior sections. This is also true of the measures introduced by the early Portuguese settlers, especially the old land measures, some of which are still in use. The English foot and inch are commonly employed in Brazil in those trades in which machinery and materials are imported from the United States and Great Britain. The *alqueire* (commonly equivalent to 24,200 square meters) is used almost exclusively for measuring great land areas. It is the only non-metric unit commonly used in official documents at the present time.

Bulgaria. The legal weights and measures of Bulgaria are metric. This system was introduced in 1888 and was made compulsory in 1891. No commercial transaction not carried on in the metric system is considered legal, and a fine is imposed for using other weights and measures. A few old Turkish units are, however, occasionally used in commerce. Instruments used for

measuring and weighing must be made according to the metric system, although this provision is waived in the case of such instruments intended for export to a country in which the metric system is not compulsory, in which case a special permit is issued by the Ministry of Commerce, Industry and Labor. The *krina* (its metric equivalent being 20 liters) has been legalized for measuring grain and the *ster* (equivalent to one cubic meter) for measuring wood. A few other units, such as the Turkish *oke*, *arshine*, *lakat*, *povolat*, *vedro*, and *stomno*, are illegal when used alone, but no penalty attaches to their use if metric equivalents are indicated.

Chile. Chile was the first Latin-American republic to recognize the metric system. Its use was made optional in that country in 1848. The law then adopted provided that the metric system should be the sole legal standard and authorized the Executive to fix the date of enforcement. It also permitted the use of certain old units for a term of ten years. The enforcement of this original law was provided for in special legislation in 1865 and again in 1891.

The metric system is today in almost exclusive use in all governmental and departmental work, in extensive use in international commerce, and in general use by the people at large. Considerable difficulty was experienced in eliminating the old Spanish and English units from the popular mind, although at the present time they have practically disappeared from general use. In navigation, however, the old English classification is in actual, although illegal, use, while the Spanish *quintal* (46 kilos) is generally used in the nitrate industry. Where old units still prevail, it is mostly in some specialized and limited field or among the people in the country districts.

Colombia. The metric system was first legally recognized in Colombia in 1853. It is today in official use in all departments of the government, having been made compulsory for such use by the law of 1857. The metric system is employed almost exclusively by educated people and those living in cities and towns, although old Spanish units are regularly used by the uneducated and the people in the interior. Storekeepers and dealers often use the old units in selling goods, cloth, for instance, being frequently called for by the *vara* and butter by the Spanish "pound;" but the greatest demand is made in metric units. The English "board foot" is widely used in the lumber industry. All goods passing through the customs house must be described in metric terms, and for all practical purposes the metric system prevails throughout Colombia.

Congo. The metric system was introduced into the Belgian Congo in 1910, at which time it was made compulsory for all pur-

poses. At the present time it is in general use throughout the province.

Czecho-Slovakia. In the territories now combined under the name of Czecho-Slovakia the metric system was introduced in 1873 and was made compulsory in 1876, while these regions were under the domination of Austria-Hungary. It is in general use at the present time.

Denmark. The metric system was legalized in Denmark in 1910 and was made compulsory for general use in 1912. It is now exclusively used in the customs and all public services, and old standards are no longer permitted except in certain special fields and in Iceland.

Exceptions are made in the case of units used by apothecaries, those used for weighing precious metals, those used in connection with foreign goods in the original packages imported, and in connection with lumber and wood products when sold to foreign countries, also those used in the measurement of ships and of land areas, for all of which old standards may be used until 1925. Retail traders using both systems are compelled to hang in their places of business a legally authorized table setting forth the equivalents of one system in terms of the other. For practical purposes, however, the metric system may be considered to be in predominant use in Denmark.

Finland. Since January 1, 1892, the metric system has been the sole legal standard of Finland. It was introduced in 1886. The use of other units is permitted among the peasantry, in the timber trade and in foreign trade, when expressly stipulated in the contract. Old units, however, are seldom used in Finland even by the peasantry, and, according to the Finnish Consul in New York, the change to the metric system was accomplished in a remarkably short time.

France. The French Government experienced considerable difficulty in securing the exclusive use of the metric system. Although first established in 1793, the system did not make much headway in France until after the passage of the law of 1837, which became effective in 1840. The old units were not generally displaced for many years afterwards. The metric system is in practically universal use in France and some of its colonies at the present time, and old measures are seldom found. However, a few old localisms persist in spite of strict requirements. This is especially true in the textile industries in which (excepting cotton manufacturing) English or old units are often used.

Germany. Germany introduced the metric system on an optional basis January 1, 1870, and the system became obligatory

for general use throughout the country January 1, 1872. According to the majority of accounts, comparatively little difficulty was experienced in introducing and enforcing the use of the metric units. This was due partly to the careful preparations which were made for their introduction. At the present time their use is general and the old measures are seldom encountered except in a few specialized fields. In the textile industries the English units are often used, and English standards are also used to a considerable extent in screw threads.

Haiti. The metric system has been in use in Haiti since colonial days. Its use has been made compulsory and it is practically the only system generally employed at the present time. English units (pounds, tons and gallons) are employed to a small extent, mainly in commerce with the United States. The pound is equivalent to 500 metric grams, but the gallon is equivalent to the United States gallon.

Hungary. In Hungary the metric system is the sole legal standard except as noted below, and old measures are used only occasionally in isolated districts. By a special law passed in 1907 certain exceptions are made to the universal application of the system. Old measures may be used for land areas; the nautical mile is allowed; and when the interest of export commerce requires, the use of other units also is permitted.

Italy. It was through the conquests of Napoleon that the metric system was first introduced into several of the provinces and kingdoms of Italy. There was considerable resistance on the part of the people and the dates of introduction and adoption of the metric system varied from 1845 to 1870 in different sections of the country. It was made compulsory in Piedmont in 1845 and not until 1870 did it become compulsory in Rome.

With the establishment of the Kingdom of Italy, a Government decree was issued, making the metric system obligatory for use throughout the country after January 1, 1863. This action was re-enforced by another law in 1874. While a few old measures are still found in Southern Italy, the change to the metric system is now for the most part complete.

Jugo-Slavia. The change to the metric system in Jugo-Slavia involves the records of two countries, Bosnia-Herzegovina and Serbia, which are now included under one kingdom.

In 1910, while under the domination of Austria-Hungary, a law was passed in Bosnia-Herzegovina which provided for the exclusive use of the metric system after 1912. During the period from 1878 to 1910 metric and Turkish units were used side by side, but today the metric system is in predominant use.

Serbia accepted the French decimal system in 1873 for its moneys, weights and measures, and the metric units have been in very general use since 1883, in which year it was made compulsory.

Latvia. The Government of Latvia passed a law in 1919 introducing the metric system and making it compulsory for all uses. It is permissible, however, to use the old Russian units where necessary until January 1, 1926.

Liechtenstein. The metric system is in general use in the small kingdom of Liechtenstein, where the introduction of the system was influenced by the proximity of Liechtenstein to Austria and Switzerland.

Luxemburg. Although the old weights and measures of Luxemburg are now practically obsolete, they are occasionally found in isolated sections. The metric was made the exclusive system in 1820. The adoption of the system in this country was due largely to the dominating influence of France.

Mexico. The metric system in Mexico was made optional in 1862, and later laws in 1865 and 1895 established it as the sole legal standard. Until 1895 the old Spanish, English and metric units were used side by side, but since that time the metric system has in a large measure supplanted the other systems. While old weights and measures are still employed to some extent in outlying districts and by small dealers and the English units are used in special fields, the metric system is today in general and predominant use.

Monaco. The metric system was made compulsory in Monaco in 1876 and is today quite generally used.

Montenegro. The use of the metric system was made compulsory in Montenegro in 1888 and its use is practically universal today. The only other measure in use is the Turkish *oke*, occasionally found in some sections of the country.

Netherlands. Some difficulty was experienced in changing to the metric system in the Netherlands, and the complete assimilation of the system was gradual. Today no other system is allowed except in shipping. Traces of a few old measures remain, however, as in the timber trade and in measuring land and draughts of ships, and among carpenters, engineers, smiths and masons, although they are not legal for such uses.

Nicaragua. The metric system was adopted as the sole legal standard of Nicaragua in 1893 and made compulsory for all uses. At the present time it is used officially in all governmental work and largely predominates in international commerce, except—as reported by the United States Consul General to Nicaragua—in

trade with the United States, in which case the people on the Atlantic coast use the English units. The Nicaraguan Consul in New York City reported that the metric system is not exclusively used by the people; many still cling to the old Spanish units. It may be said, however, that the metric system is in general predominant use in Nicaragua.

Norway. The metric system was made compulsory for government use and optional for other uses in Norway in 1879 and compulsory for all uses in 1882. Except in the fishing trade, other units than the metric are not permitted and are seldom used at the present time.

Paraguay. The metric system was made the sole legal standard of weights and measures in Paraguay in 1899, but there is no penalty attached to the use of other units. Today it is used almost universally. The English and old Spanish units are found only to a very small and disappearing extent even in the interior. The "league" is still used to indicate distances and in measuring land. The Government provides for instruction in English weights and measures in the schools, but this is intended only to facilitate foreign trade development and is not an effort to supplant the metric system.

Philippines. The metric system was introduced into the Philippines in 1849 when it was adopted by the mother country, Spain. The Philippine Tariff Act of 1901 provided for the continued use of the metric system, and the Philippine Commission passed an act in 1909 designating the metric as the fundamental and only legal standard. This act also provided for the use of the English system in the purchase and sale of manufactured lumber, and for the designation of sizes, descriptions or specifications of articles manufactured in foreign countries in the units of any system. As a result such expressions as "ten meters of 3-inch pipe" are frequent. At the present time the metric system is used generally throughout the Islands, although old Spanish units still prevail to a small extent among local dealers and especially among the natives in the interior, and English units are occasionally found also. The hemp industry is still based on the old standard of the *picul*.

Poland. The metric system was introduced at an early date into German Poland and Austrian Poland. Old Russian units were common in Russian Poland, but are little used at the present time. Poland officially adopted the metric system in 1919, making it compulsory for all uses throughout the Republic. Even at that time, however, it was already in very general use.

Portugal. A decree providing for the gradual introduction of the metric system was issued in Portugal in 1852, but subsequent

statutes were necessary to bring about the change and the system was not brought into universal use until 1872. Considerable difficulty was experienced in the general adoption of the metric system by the lower and the agricultural classes of people, among whom old weights and measures such as the *arroba* and the *alqueire* are quite generally employed even today, though they are not recognized as legal standards by the Government.

Roumania. The metric system was introduced into Roumania in 1884, at which time it was made compulsory for general use. Although the metric system is now generally used, the Turkish standards are still found to some extent.

Spain. Spain did not adopt the metric system until 1849. The system was made optional at that time and compulsory in 1855. On receipt of copies of the international prototype meter and kilogram in 1892 the original law was restated and the metric system established as the sole legal standard for the country. Passive resistance to the change was manifested when the laws of 1855 and 1892 were put into force, and further enforcement regulations were provided for in legislation passed in 1917. To-day the metric system is used very generally, except among the peasantry and by certain other classes who still cling to the old Spanish system.

Sweden. Sweden adopted the metric system as the sole legal standard in 1879 and made it compulsory for all uses in 1889. Since that time its use has become almost universal, and the old units are now seldom found. In a few sections the old Swedish *mil*, equivalent to six and one-third English miles, still prevails; and occasional English units are found, mainly in the lumber industry and in machine shops.

Switzerland. The metric system was established as the sole legal standard of weights and measures by the federal law of July 3, 1875. The names of old units are still used to some extent by the country people, but they are gradually being replaced and have in some instances lost their real value and become multiples of the metric units.

Tunis. The metric system was made compulsory for all uses in 1895, and has since almost entirely taken the place of the old units of Tunis. Corn, however, is still sold in *kaffis* and *whibas*.

Uruguay. The metric system was introduced and made compulsory for all transactions in Uruguay in 1862. Another law in 1894 made it compulsory in governmental work and for general use by the people at large. This later law was very stringent and penalties were imposed for the use of other units, the only exception allowed being in the publishing of international

trade catalogues, in which it was permitted to print the weights and measures of foreign countries. In all documents relative to real estate surveyed prior to October 2, 1894, mention of old measures is also allowed, although these measures have to be reduced to metric terms. By decree of 1918 special provision was made for a still stricter enforcement of the compulsory metric law. The metric system has today practically supplanted the old units, although the latter are still found in rural districts. English units are used in the lumber industry, by carpenters, in machine shops and for marine measurements, but for official use all measures must be stated in metric terms.

Venezuela. In Venezuela the metric system has been in official use since 1857 but was not employed to any extent in private business and commerce until 1912. During that year an Executive decree was issued making the metric system the sole legal standard in the Republic. It is now used in government work, in international commerce, and quite generally by the people at large. Old Spanish units are still used by the country people, but this practice is fast disappearing. English units are also occasionally used in commerce and industry, but only to a small extent.

(b) Countries in which English System Predominates

Australia. Australia has not yet recognized the metric system, and the English system is the sole legal standard. The indications are that the metric system will not be adopted by Australia until it has first been accepted by Great Britain. The metric system is used, however, to a very limited extent by automobile and electrical supply houses and in science and research.

British Guiana. The English system is the sole legal standard of weights and measures in British Guiana, although the metric system is compulsory for use in the government chemical laboratory. There is no tendency and apparently no intention to make the metric system a legal standard.

Canada. The use of the metric system was made permissive in Canada by a law passed in 1871. As in the United Kingdom, however, the metric system is used only to a very limited extent. The English standard is almost universally employed.

Liberia. The metric system is seldom found in Liberia, the English units being generally used.

New Zealand. The official standard of New Zealand is the English system, which is used in practically all transactions. The metric system has never been officially recognized and is used only to a small extent in the fields of science and research. In 1908 an act was passed permitting the Governor by proclamation

to establish the metric system from and after any date to be determined by him. No such proclamation has been issued, however.

Porto Rico. The metric system was first introduced into Porto Rico in 1849, coincident with its adoption by Spain. Up to 1902, the English, Spanish and metric systems were used side by side. In 1902 the metric system was made the legal standard of Porto Rico, but the law was not enforced. In 1913 an amendment was passed placing the metric and parts of the English system on an equal basis. Both the English and metric systems are in general use at the present time, but the former is gradually supplanting both the metric system and the old Spanish units.

Russia. Under the terms of the law of June 16, 1899, the metric system was made permissive throughout Russia, but it has never been accepted as an exclusive standard. As early as 1833 the Russian units were defined in terms of the English foot, which is the basis of linear measure in that country. The legal unit is the *sagene*, which is equal to seven English feet. A standard for this unit was constructed with great exactness and compared with the English yard, and from it various other measures were derived. Metric units are used for scientific work, by doctors and pharmacists, in the medical departments of the army and navy, and in the customs service. The English and derived Russian units, however, are almost universally used in commerce and by the people.¹

San Domingo. On May 22, 1867, the metric system of weights and measures was adopted as the sole legal standard of the Dominican Republic, and the legality of the system was reaffirmed by a presidential proclamation in 1913. No serious attempt, however, has been made to enforce this decree, so that the metric system has never come into general use. It is now employed solely by customs authorities, and with few exceptions the English system is used by the general public. The predominance of the English units is probably due to the large amount of commerce carried on with the United States. Spanish units are also used to some extent.

South Africa. There is no national statute governing weights and measures in the Union of South Africa, although an attempt is being made to have the Government consolidate the laws of the four Provinces of the Union on this subject. In the Cape Province the weights and measures of Great Britain were established as the standard in 1858. The metric system is not in use in South Africa except among chemists. The English standards are used principally, and a few old Dutch units still survive in the various Provinces.

¹ Information is lacking as to whether or not the Soviet Government has made changes in standards hitherto in force.

Straits Settlements. Ordinances No. VII of 1886 and No. XXIV of 1910 designated the system of weights and measures to be used throughout the Straits Settlements as the English standard. The metric system is very little used.

United Kingdom. The metric system was first introduced in the United Kingdom in 1864, and in 1897 the system was made permissive for all uses. It is rarely used, however, except in quotations for foreign countries and, to a limited extent, in the manufacture of products exported to metric countries, in scientific and research work and in the electrical industry. The British imperial standards are used almost universally.

United States. Congress authorized the permissive use of the metric system in the United States in 1866. Its use is required in the medical work of the Army (order approved by Secretary of War, April 13, 1890) and Navy (order approved by the Secretary of the Navy, April 15, 1878), and in the Public Health Service (Regulation promulgated by the President, November 21, 1902). It is used also by the Coast and Geodetic Survey in its triangulation work, but the results are stated in both metric and English units. It is employed principally in science, in education, in certain modern technical processes, in medicine and pharmacy, in electrical work, to a limited extent in manufacturing (mainly in the manufacture of fine instruments and other specialized products), and to some extent in marking products for export to metric countries. Everything considered, however, its use is very limited, and the English system is employed almost universally in manufacture, domestic commerce, and by the people generally.

(c) Other Countries

Abyssinia. Local units are in general use throughout Abyssinia and there is little evidence of the influence of either the metric or English system.

Afghanistan. The weights and measures situation in Afghanistan is similar to that in Abyssinia.

Armenia. Turkish, Russian and local units are in general use in Armenia.

Bolivia. The metric system was introduced into Bolivia about 1870 and was used as the official standard in governmental work until 1893, when it was made compulsory for such uses. The Government has made an effort to bring about the general use of the metric system, and it is used in all large commercial transactions, but the smaller merchants, business men and the people at large still cling to the old Spanish units.

China. In the tariff settled by treaty between Great Britain and China, the *ch'ih*, equivalent to 14.1 English inches, was adopted as the legal standard. The units of weight and length vary throughout the Republic, the *ch'ih*, for example, ranging from 9 to 16 English inches, and the *chang*, equivalent to 10 *ch'ih*, varying in proportion. At the Treaty Ports the use of the treaty standard for *ch'ih* and *chang* is becoming common. The law of 1914 established a duplicate system of weights and measures, one the metric system and the other based on local units. Local units are used principally, although English units are generally used in the cotton trade, and both English and metric units also are used at the Treaty Ports.

Costa Rica. The metric system was introduced into Costa Rica in 1885 as the sole legal standard. In nearly all legal and official transactions and in recording measurements of land the metric system must be and is used. The retail merchants, however, still use the "pound" for their weights, and the *vara* and other Spanish units for the measurement of length, so that outside of official and land transactions the English and old Spanish units are used more extensively than the metric units.

Cuba. Being a Spanish dependency at the time, Cuba introduced the metric system in 1849, coincident with its introduction in Spain. The metric system is now the sole legal standard recognized by the Government of Cuba.

The enforcement of weight and measure laws has, however, been vested in the municipalities or in local departments of weights and measures. This has resulted in the almost universal retention of certain old Spanish units in retail and local wholesale trade, and also in the use of English standards. The *arroba* is commonly used in the interior in the sale of sugar cane; and the *caballeria*, a Cuban term, is commonly employed in the sale of large tracts of rural land. The metric system is used, however, in liquid measures, and for customs purposes all weights and measures must be reduced to metric equivalents.

The influence of the United States and Great Britain is evidenced in the use of English weights and measures in export trade. There is a tendency toward the general use of the metric system, but this seems unlikely to be accomplished unless the United States and Great Britain discard the English system.

Ecuador. Although the metric system was introduced and made compulsory for official purposes in Ecuador in 1856, it has never been made compulsory for private business. Imports to Ecuador are based on the weights and measures of the country from which they come, but the metric system is used for export trade. The

old Spanish units still prevail in most private transactions and among the people in the interior.

Egypt. The metric system was made permissive for all uses in Egypt in 1873 and in 1892 became compulsory for governmental work. The law of September 26, 1914, defined the principal units of Egyptian weights and measures in terms of the meter. Today the metric system is generally used by government officials, engineers, architects and contractors, but most of the wholesale and retail trade is carried on in the old Egyptian units.

Greece. Although the metric system was introduced into Greece by royal decree in 1836 and is today used to a considerable extent by the Government, it has never been accepted by the masses of the people. The old Turkish and Greek units prevail. The metric system was made compulsory in December, 1920, but data as to its progress since that date are not as yet available.

Guatemala. Since 1894 the metric system has been compulsory for all governmental and departmental work in Guatemala, but not for other purposes. The metric system is used in international commerce with Europe but not with North America. It is today used only to a small extent by the people at large, the principal units being the Spanish, which vary with each department, so that almost every district has different local units of its own. Customs authorities report exports in *quintales* and imports in kilos. Ship tonnage is measured in long tons; distances are expressed in kilometers by the foreign population and in variations of the Spanish system by the natives.

Hedjaz. Turkish and Arabian units are in general use throughout Hedjaz and there is no evidence of the use of the metric system.

Honduras. The metric system has not been popularly accepted in Honduras. It was recognized as the legal standard in 1897, but the English pound and yard and old Spanish units are still in general use. Except in the case of modern land measurements and customs tariffs, for which the metric system is used, and of old land measurements, for which the old Spanish system is used, the measures used in Honduras are a composite of the English standards and Spanish *libras*, *varas*, etc.

India. While the metric system was introduced into India in 1871, its use has never been popularized. Weights and measures vary not only from district to district but also for different communities within the same district. Local units, such as the *maund*, *seer* and *tola* are principally used. Discussion of the weights and measures question, which still continues in some sections, has

never resulted in an agreement for the adoption of any particular system.

Japan. Although the metric system was legalized in Japan in 1891, at which time the old measures were reorganized and based on those of the metric system, it is not the sole legal standard.¹ Local Japanese units are in general use and these, combined with the metric units, constitute the legal standards. The metric system is not generally used, except in the army, in medicine, in technical and scientific circles, and to a very limited extent in commerce. English units are very commonly employed.

Mesopotamia. Turkish and local measures are in general use in Mesopotamia. English and metric units are seldom found.

Morocco. Local units are in general use throughout Morocco and there is little evidence, if any, of the influence of the metric or English systems.

Nepal. The weights and measures situation in Nepal is similar to that in Morocco.

Oman. As is the case in Morocco and Nepal, local units are in general use throughout Oman and neither the metric nor the English system has gained a foothold.

Palestine. In Palestine the Turkish and Egyptian units are chiefly used and the influence of other systems is seldom felt.

Panama. The metric system was first introduced into Panama in 1853, when that country was a part of the Colombian Republic. It was made compulsory for governmental and official use in 1857, and by an Administrative Code approved August 22, 1916, the use of the metric system was provided for "in all official and commercial" matters. In private transactions and in local trade and commercial circles both the English and the metric systems are in general use, except in the interior where old Spanish and English units are largely employed. The *vara* is, however, commonly used in all sections for measuring cloth.

Persia. The weights and measures situation in Persia is similar to that in Abyssinia, Afghanistan, Morocco, Nepal and Oman.

Peru. The metric system was made the legal standard for Peru by the law of December 16, 1862, but from the beginning it was not used even by the Government. On April 12, 1916, the Municipal Council of Lima and Callao ordered all commercial firms, which up to that time had been using the Spanish system, to adopt the metric units. Despite this action, however,

¹ According to recent reports (New York *Evening Post*, May 3, 1921) Japan has recently passed a weights and measures Act "making the metric system the sole legal standard at the end of twenty years."

the old Spanish system still persists in local retail trade, in the interior and in agricultural pursuits. In international commerce the weights and measures of the country with which the trade is conducted are commonly used. The metric system is not used by the people at large for the measurement of length, the Spanish *vara* being employed for this purpose. For weighing purposes the metric system is used for both dry and liquid commodities. The Peruvian Consul in New York City reported that the Government has been unable to enforce the use of the metric system among the people at large and that old Spanish units are still in common use.

Salvador. By decree of the Executive, dated August 29, 1885, the metric system was established for official use in Salvador. In 1912 it was made obligatory for all transactions, both public and private. Today the metric system is in general use by the Government, and in all legal transactions, but in private commercial transactions, and especially among the illiterate, old Spanish units predominate. In commerce the system of the country dealt with is used, although the metric system is encouraged. Every effort is being made to establish the metric system as the exclusive one in Salvador, but this has not yet been accomplished.

Siam. In Siam the metric system was made compulsory for public works in 1889 and for railways in 1892. For other purposes there are no standard weights and measures. Local units are in general use by the people.

Syria. Turkish and local units are generally used in Syria and the influence of the metric system is seldom felt.

Tripoli. Through the influence of Italian control the metric system was introduced into Tripoli in 1913. The old Turkish units, however, are still used to a large extent.

Turkey. The use of the metric system was made permissive in Turkey in 1886 and by the decree of 1892 it was made obligatory in Constantinople for all uses. This decree, however, has never been enforced, despite the adoption of very severe measures. In 1915 the Turkish Government adopted the metric system as its official standard, but even today it is little used except officially, and in many interior sections is practically unknown. The old Turkish units still predominate.

EXPERIENCE IN MAKING CHANGE TO METRIC SYSTEM

The first part of the preceding analysis deals with thirty-seven countries in which the metric system is today in predominant although not exclusive use. In all of these countries other systems of weight and measure had preceded the introduction of the metric.

It was apparently necessary, before its predominance could be assured, that the metric system be compulsorily established as the only legal standard and the other systems in use suppressed by force. In short, where the metric system has superseded earlier local systems, it has done so mainly through the force of compulsory law. Even with such aid its general establishment has met with considerable difficulty and in many metric countries is still far from complete.

The difficulties France experienced in making the change have been pointed out in some detail above.¹ Her later compulsory law became effective in 1840, but even today, eighty years later, certain old measures have not yet been fully displaced. In Belgium, Luxemburg, and the Netherlands the metric system became compulsory in 1820, over one hundred years ago. In Luxemburg old local measures are still occasionally used today, and in the Netherlands local measures are still used in the timber trade, in carpentry, engineering, blacksmithing, land measurements, and in measuring the draughts of ships. In Belgium the early law was not vigorously enforced, and it was necessary to pass an additional measure in 1855 to secure effective suppression of the old units.

In Spain and Portugal even more difficulty seems to have been experienced. The first compulsory law in Spain was passed in 1853, but other supplementary measures were passed in 1855, 1892, and in 1917. The use of old local systems still prevails among the peasantry and among certain other classes, although such measures are not legally recognized. In Portugal the metric system was established in successive stages, beginning in 1862 with the compulsory use in official governmental transactions. In 1872 it was made compulsory for general use. A few old measures still remain today, though without legal recognition. In Italy the system was made compulsory in 1863, and its use was further enforced by additional legislation in 1874. Today, though the change is practically complete in Northern Italy, some old measures are still used in the southern provinces.

In Latin America, with the exception of Colombia, similar difficulty in making the change to the metric system has been experienced. In Mexico the metric system was made compulsory by legislation in 1862, in 1865, and 1896; in Brazil, in 1864 and 1874; in Chile, in 1865 and in 1891; in Argentina, in 1879 for governmental use and in 1887 for general use; in Costa Rica, in 1885; in Nicaragua, in 1893; in Uruguay, in 1894 and 1918; in Paraguay, in 1899; and in Venezuela, in 1912. In all these countries, whether the metric system was made compulsory early or late, the old local units (mainly Spanish) are still in use to a greater or less extent. In Mexico the system was not readily accepted by the people, and Spanish, metric and English units have existed side by

¹ See pp. 11 and also 167-168 of present report.

side for many years. In Brazil it took the passage of stringent measures on two occasions to secure any appreciable suppression of local units. In Uruguay for thirty-two years extreme difficulty was found in enforcing the compulsory law and it required an additional decree in 1918 to bring the metric system into general use.

Germany, Austria and Hungary passed compulsory metric laws between 1872 and 1876. In Germany careful preparations were made for the establishment of the system and it was readily adopted by most of the people. At the present time its use is general, although old measures are frequently found. In Austria binary divisions are specifically allowed for liquid and dry measures, and the use of the English nautical mile and ship-ton are permitted in navigation. In Hungary the metric system was quickly assimilated, but in 1907 a law was passed allowing the use of the English nautical mile and the old units for land measurement.

In other European countries in which the metric system was brought into compulsory use between 1876 and 1892, difficulties in suppressing local units are again evidenced. In Switzerland two compulsory laws were passed, one in 1877 and another in 1887, but the names of old units are still retained to some extent by the country people today. In Norway the metric system was made compulsory for governmental use in 1879 and for general use in 1882. Here the suppression of the old units has been quite successful outside of the fishing trade, where old units are permitted. In Bulgaria the use of old units is still permitted today, provided metric equivalents are indicated. In certain other countries also where the compulsory use of the metric system was begun during this period, a general suppression of local units has not yet been accomplished.

In the past twenty-five years the metric system has been compulsorily adopted in about ten countries, in some of which express recognition is given to the difficulty the suppression of the older units entails. In Denmark, which made the metric system compulsory for customs and public service in 1910 and for general use in 1912, exceptions are allowed in apothecaries' weights, precious metals, imported goods, lumber, ship measures, and measures of land until 1925. Today the old units are still employed by most of the people. In Latvia the metric system was made compulsory in 1919, but the use of the old Russian measures is permitted under certain conditions until 1926. Despite its compulsory laws Salvador has not been included among the metric countries because of the fact that the metric system has, up to date, made little headway there. The system was made obligatory for official governmental use in 1886 and for all transactions, both public and private, in 1912. The old measures, however, are still extensively used in commerce and by the people at large. A similar situation exists in Costa Rica.

CHAPTER IV

WEIGHTS AND MEASURES IN THE UNITED STATES

In the early days of the American colonies the weights and measures, like the coinage, were based almost entirely on those of the mother country, and where statutes were enacted providing for standards, these were derived from the standards of the Exchequer of England.¹ Inasmuch as Great Britain was the chief source of supply as well as a market for merchandise and the commercial dealings of the colonies were largely with her people, such a condition was but natural. The principal units used at this time were the yard, the avoirdupois pound, the gallon and the bushel. More or less authentic copies of the English standards had been brought over from time to time and adopted by the different colonies. Divergencies in these weights and measures were, however, quite common.

Following the Revolution came the recognition of the need of a single national system of currency and of weights and measures. The Articles of Confederation adopted November 15, 1777, gave Congress the power both to regulate coinage and to fix the standard of weights and measures throughout the United States. The Federal Constitution adopted later, in turn provided Congress with similar power. With respect to coinage Thomas Jefferson prepared an elaborate report, and as a result a decimal system was adopted on July 6, 1785;² but on the question of weights and measures Congress was slow to act.

EARLY PROPOSALS REGARDING UNIFORMITY

President Washington in his first message to Congress made special reference to weights, measures and currency, as "a subject of great importance," which, he was persuaded, should be "duly attended to." Accordingly, the House of Representatives in 1790 referred the matter to a committee and to Thomas Jefferson, Secretary of State. Jefferson's first proposal, after several months' study of the subject, was to suggest as a new standard of linear mea-

¹ Hallock and Wade, *op. cit.*, p. 109.

² United States. "Journal of Congress." Vol. 38, No. 1.

sure the selection of a cylindrical rod of iron 58.72 inches long, based upon the length of a second's pendulum. He further submitted two distinct plans for securing a uniform system of weights and measures.¹ His first plan was to adapt a new system from the English system and base it upon his proposed second's pendulum standard. His other plan was a strictly decimal system, the purpose of which was, to quote his words, "to reduce every branch to the same decimal ratio already established for the coin, and thus bring the calculation of the principal affairs of life within the arithmetic of every man who can multiply and divide plain numbers."² The fundamental foot in Jefferson's decimal plan differed but little from the foot then and now in use. It was derived by taking one-fifth of the length of his proposed standard rod 58.72 inches long, and from this unit building up a series of shorter and longer units for linear measure. The units of area, volume, capacity, and weight were to be based upon the linear unit.

In his second and third messages to Congress, Washington again called attention to the need for a uniform system of weights and measures. In 1792 a specially appointed Senate Committee recommended the adoption of Jefferson's decimal plan and included in its recommendation directions for the "scientific construction of a standard of length to be divided into five equal parts, each of which would correspond to a foot" and information relative to the measures for the survey of land, units of weight, etc. No action was taken, however, at this time nor for several years afterward.³

It has been suggested that the reason Congress did not adopt either of Jefferson's proposals was its desire to await the outcome of the agitation for a change in weights and measures then taking place in France and Great Britain. France was constructing her metric system and Great Britain was considering a change.

INFLUENCE OF DEVELOPMENTS IN FRANCE AND GREAT BRITAIN

France about this time had adopted the metric system. In 1795 a committee from the House of Representatives of the United States made a study of the French plan in connection with Jefferson's decimal plan. This study resulted in recommendations of a general nature involving scientific experimental work, which, however, never received authorization from Congress. Political events preceding the war of 1812 took up the attention of Congress at this time, so that further consideration was not given to the subject of weights and measures until 1814, during which year the Coast

¹ "The Works of Thomas Jefferson," edited by H. A. Washington, New York, 1884, vol. 7, pp. 472-495.

² United States. "Journal of the House of Representatives, Second Congress, First Session," p. 106. (Childs and Swayne.)

³ United States. "Journal of the Senate," Second Congress, First Session, pp. 173-174.

and Geodetic Survey, with the idea of having a definite standard of length, imported from England an 82-inch brass bar scale made by a London manufacturer named Troughton. Thirty-six inches taken on this scale were adopted as the standard yard for use by the Treasury of the United States and by other government departments. For its official and triangulation work, and for its precise leveling, magnetic work and gravity investigations, however, the Coast and Geodetic Survey finally selected the meter, which has been used for such purposes ever since, although the results of its triangulation and precise leveling are stated in both meters and feet "in order to give the results to the public in the way the public demands."¹

The development of weights and measures in Great Britain and France was not very encouraging at that time. In France the compulsory metric law had been repealed, and the ancient weights and measures were in use side by side with the metric system. In England the situation was not much better; a new Imperial gallon and a new bushel had been adopted, while several old gallon units remained in use. Neither of the new English measures was in use in the United States, and hence this country could not give complete adherence at that time either to the standard employed in England or to the one in France without introducing certain changes in the weights and measures already in use; nor was there any assurance that the metric system would be permanent.² An authoritative treatise³ attributes the hesitation of the United States in considering or adopting the metric system during this period to the fact that its establishment in France was meeting with considerable difficulty.

ENGLISH SYSTEM UNIFIED AND STANDARDIZED

Unquestionably the most important development in the early history of weights and measures in the United States was the survey by John Quincy Adams, which resulted from President Madison's suggestion in his message to Congress, in 1816, that a definite uniform system of weights and measures was urgently needed. Mr. Adams was then Secretary of State and undertook a thorough analysis and study of the entire subject. This study consumed four years, and the results were embodied in a 244 page report, submitted February 22, 1821, which has since been designated on high authority as "a classic in American metrology."⁴ Mr. Henry R. Towne recently said of this report that "there has never been anything published on the subject since then which is so compre-

¹ Jones, E. L. Director of Coast and Geodetic Survey, June, 1920. (Letter to N. I. C. B.)

² Fischer, L. A., "History of Standard Weights and Measures of the United States," Bulletin No. 17 of the United States Bureau of Standards, Vol. 1, p. 368.

³ Hallock and Wade, *op. cit.*, p. 115.

⁴ Hallock and Wade, *op. cit.*, p. 116.

hensive, nor by so high an authority." It deals with the subject from many angles, includes a survey of the weights and measures situation existing in the various states at that time, and presents the merits of both the English and metric systems so fully and impartially that it has, up to the present time, been quoted at length by leading advocates of each system. It is without question a most remarkable report written under considerable difficulty and with practically no weights and measures literature to draw from.¹ Mr. Adams' report recommended "that no present change in the weights and measures of the country be attempted" and that the English units then in use be retained. The reason for this recommendation was that Mr. Adams felt that the benefits of the metric system had not yet evidenced themselves and that only after these benefits became manifest in France would it be worth while to consider the system for possible adoption in the United States.²

During the time that Mr. Adams was engaged in his study a committee of the House of Representatives was also considering the question of weights and measures. This committee had already submitted a report on January 25, 1819, essentially advising the adoption of the first plan proposed by Jefferson, which was an adaptation of the English system, and recommending that standards for the yard, bushel and pound conforming to those in most common use be established under the direction of a commission to be selected by the President.³ The system thus standardized, if satisfactory to Congress, was to be declared the standard for weights and measures in the United States. Congress considered this recommendation of the House of Representatives in connection with Mr. Adams' report and finally evaded the whole matter by making a negative recommendation.

Mr. Adams' report, however, had its effect, for on May 19, 1828,⁴ Congress passed an act establishing the Imperial standard troy pound of England as the standard troy pound for the Mint of the United States, and about the same time took cognizance of the extreme diversity in the weights and measures used by the different custom houses of the country. While Congress had previously been considering the matter, many of the States had, independently of one another, secured and adopted "standards." Most of these were brought from England; nevertheless, standards of the same denomination differed widely among themselves. On May 29, 1830, therefore, the Senate passed a resolution ordering the comparison of the local custom house standards with those standards kept in the Treasury Department. It was found that

¹ Adams, Henry. "The Degradation of the Democratic Dogma," 1920, Chapter 2.

² John Quincy Adams. "Report on Weights and Measures," 1821, p. 135.

³ Hallock and Wade. "Evolution of Weights and Measures and the Metric System," p. 116.

⁴ Revised Statutes of United States 3548, Ch. 131, Section 50, 17 Statutes 432.

there was a great lack of uniformity throughout the various customs districts. As it happened, the standard measure of length procured by the Coast Survey in 1814 corresponded exactly to the unit of length established as the legal unit of Great Britain in 1758. It was felt, therefore, that the unification of weights and measures in the United States could best be carried out through the Coast Survey. Accordingly, the Treasury Department arranged that there should be constructed in the office of the Coast Survey a number of complete and uniform sets of standards of weight and measure for distribution throughout the United States "to the end that a uniform standard of weights and measures might be established." In July, 1838, balances for the accurate comparison of weights were ordered constructed and distributed to the states and territories.¹

Before copies of the standards could be constructed it was necessary for the Treasury Department to determine upon certain units and to adopt material standards representing them. Those finally adopted were: the yard of 36 inches, the avoirdupois pound of 7,000 grains, the gallon of 231 cubic inches, and the bushel of 2,150.42 cubic inches (the Winchester bushel). The standard yard adopted was 36 inches measured on the 82-inch brass bar, already referred to, prepared in London for the Coast Survey.² The pound standard was also fixed in practical accord with the similar standard of Great Britain. The gallon and the bushel adopted by the United States Treasury Department were not in accord with the legal capacity standards of England adopted there a few years before, but were derived from the earlier English standards because it was found by investigation at the time that they were the ones in most general use here.

By 1856 the various states of the Union were supplied with sets of standards through the United States Coast Survey, and not long after their receipt the individual states enacted statutes establishing them as their standards of weight and measure. Thus was the English system unified and standardized for the entire country, and from that time forward the units thus standardized for the United States came to be used more and more as the basis for the great industrial development that followed, until today they are basic and interwoven into the commercial and industrial life of the nation.

LATER METRIC DEVELOPMENTS

Interest in the metric system, however, did not disappear with the establishment of the English system as the standard for this

¹ United States. Bureau of Standards. "Laws Concerning the Weights and Measures of the United States," 1904; also Hallock and Wade, *op. cit.*, pp. 120, 121.

² Fischer, L. A., "History of Standard Weights and Measures of the United States," Bulletin Bureau of Standards, Vol. 1, p. 370.

country. In February, 1854, the American Geographical and Statistical Society presented a memorial to Congress urging the appointment of a scientific commission to consider a decimal system of weights and measures. During the following ten years, moreover, the metric system spread to many countries outside of France, especially to those of Latin America, and the influence of this rapid spread made itself felt in the United States, so that on July 28, 1866, an act was passed by Congress authorizing the use of the metric system in this country. This act¹ provided that it "shall be lawful throughout the United States of America to employ the weights and measures of the metric system," and also provided for the establishment of a series of legal tables of equivalents between the English and the metric units so that conversions could be readily made.² In the same year acts were passed authorizing the Treasury Department to furnish the States with metric weights and measures and authorizing the Post Office Department to use metric weights and measures for foreign mailing and other purposes.

In 1871 the United States Government accepted an invitation from the Government of France to send delegates to Paris for the purpose of forming an international commission to construct new metric standards. Out of this convention grew the agreement to establish and support the International Bureau of Weights and Measures, to which the United States became a party. In 1889 the international prototype standards of the standard meter and kilogram were completed by the International Bureau, and sets were distributed to the United States as one of the 19 nations adhering to the convention.

An act passed by Congress on March 3, 1893, established a standard scale for the measurement of sheet and plate iron and steel, expressed in terms of both the customary and metric measures. On April 5 of the same year, the Secretary of the Treasury approved an order from the Chief of the Bureau of Standards recognizing "the international prototype meter and kilogram as fundamental standards," and directing that the customary units—the yard and the pound—be derived therefrom in accordance with the Act of July 28, 1866.³ This order, however, had no legal force, since the power to fix the standard of weights and measures is vested in Congress alone, so that the order merely served to de-

¹ United States Revised Statutes 3569.

² In these tables the permissive meter for the United States was defined as containing 39.37 inches. The meter as defined in England is 39.370113 inches long. There is, therefore, a difference of about three thousandths of a millimeter in the meter as defined in these two countries. There is no difference to-day between the Imperial standard yard of Great Britain, according to which the length of the foot and inch are defined, and the yard standard of the United States, since the Imperial yard is fixed as the standard of the United States also. See Stutz, C. C., "The British and American Inch Identical." *American Machinist*, May 5, 1921.

³ United States. Coast and Geodetic Survey, "Fundamental Standards of Length and Mass," Bulletin No. 26. Republished as Appendix No. 6, United States Coast and Geodetic Survey Report, 1893.

termine the basis of comparison between the meter and the English units. The act of July 12, 1894,¹ defined and established units of electrical measure, which are the international electrical units related to the metric system definitely agreed upon at a congress held in Chicago in 1893.

Since the first permissive metric legislation, passed in 1866, various bills have been introduced into Congress to establish the metric system as the sole legal standard of weights and measures. The general tendency of all these bills has been to make the system compulsory for official governmental use and gradually to extend its compulsory use to the people at large. During the period from 1906 to 1916, there was a lapse of specific effort looking toward further metric legislation, but since 1916 several metric bills have been introduced, the latest, Senate 2267, introduced July 18, 1921. Briefly, this bill provides for the compulsory adoption of the metric system as the sole legal standard of weights and measures after ten years from the date of its passage.

During the past generation, however, considerable opposition has developed among various classes and interests in the United States toward the compulsory adoption of the metric system here, and organized effort has been instituted to simplify the English system where necessary and prevent its abolition by compulsory law.²

PRESENT SITUATION

The issue between the metric and English systems has been more and more sharply drawn in recent years. Today the United States and Great Britain and their dependencies have become the main objects of pro-metric propaganda.

The situation in the United States, however, is today quite different from the situation that confronted other important countries in making a change from their local systems to the metric. In other countries considerable confusion of weights and measures existed at the time the change was brought about. In other countries, also, the change took place before the industrial life of the nation had become organized and standardized to the extent that modern production makes necessary. The countries outside of Europe which have adopted the metric system have little or no organized industries in the modern sense.

In the United States today there is, in the first place, no fundamental confusion with respect to weights and measures. Furthermore, the United States unquestionably stands in the forefront of the great industrial and manufacturing nations. Its highly organ-

¹ United States Revised Statutes 3570, Ch. 231, Sec. 1, 27 Statute, p. 746.

² See Chapter XIV of present report.

ized industry is based on the English units of weight and measure and most of its vast technical literature is written in this system. All things considered, therefore, there does not exist in this country the great incentive to a change found in other nations where confusion was the rule until the metric system was adopted.

In consequence the situation today narrows itself down to the question whether the advantages to be gained warrant the compulsory adoption of one unified system, namely, the metric, in the place of another unified system, namely, the English, which latter is moreover the established system and enters so intimately into the present industrial organization of the nation. It is not a question of allowing the use of the two systems side by side and giving the metric the opportunity of supplanting the English, because the metric has, as a matter of fact, been a legal system in the United States since 1866, and anyone who so desires and finds it more convenient and practical may use it. The question is, shall the United States discard the English system of weights and measures entirely and absolutely and in its place substitute by compulsory law the metric system as the sole standard?

PART II

Use of English and Metric Systems in Special Fields

In Part I a picture is drawn of the national or governmental status of weights and measures. The subjects dealt with in Part II cut across such governmental divisions, for which reason they may be regarded as providing a cross-section of the situation presented in Part I. A nation is made up of a number of special fields of activity in which the question of a change in weights and measures plays a little or a greater part, depending on the nature of the field and the ease or difficulty with which a change from an established to another system could be accomplished. Part II examines the characteristics of various special fields with little regard to national lines, except that in each chapter the analysis is finally related to the question of a compulsory change to the metric system in the United States.

CHAPTER V

IMPORTANCE OF WEIGHTS AND MEASURES IN VARIOUS FIELDS

This chapter first takes up the general factors affecting the use of weights and measures in various fields, and secondly, outlines the major fields of industry in the United States as related to weights and measures.

FACTORS AFFECTING USE

Two important groups of factors are to be considered in discussing the use of weights and measures in special fields of endeavor, namely, national or governmental, and industrial. National factors have to do with the effectiveness of the laws aiming at unification of the weights and measures in a country, while industrial factors center around the reasons for the persistence of old customs in spite of attempts at national uniformity. In addition it is necessary to consider questions having to do with the ease or difficulty with which various fields in the United States might be able to change from the weights and measures in use.

Influence of National Laws

It was pointed out in Part I¹ that there has been more or less difficulty, in countries substituting the metric system for earlier systems, in securing the universal adoption of the new units. In general, the completeness with which various special fields in metric countries have adopted the metric system has been seen to depend in large measure upon the stringency and comprehensiveness of laws bringing about its adoption. The effectiveness with which a law has been enforced is likewise important.

It is found that in those countries in which the metric system has been made optional only, its voluntary use has not extended much beyond such fields as science and those branches of manufacturing making use of minute measurements. In those countries in which the metric system has been made compulsory for government uses, it has spread little beyond official departments. Even where legislation makes the metric system compulsory for all uses

¹ See pp. 33-35.

and the law is thoroughly enforced, very few metric countries have achieved its adoption outside of legal transactions and in wholesale domestic trade; and in a number of countries specific exemptions have been made allowing the use of old units in certain fields, such as in the timber trade, in land measurements, in engineering, in measuring drafts of ships, and in other fields. In the field of domestic retail trade, which in practice marks the limit of compulsory metric enforcement, it has frequently happened that a compromise has been effected between the old terminology and the metric units, the old quantities being given the nearest equivalent metric name or the nearest metric unit being called the old name. In this way legal requirements have been met while the old national or local names have been retained.

Such basic industries as agriculture, mining and manufacturing have, however, been little affected by the operation of compulsory metric laws. Thus in France, where the metric system is most strongly entrenched, we find instances of the manufacture of products still being carried on in the old units and quotations of goods being made on the basis of the old measures, although these, when the sale is actually made, must meet the legal requirements by being translated into metric terminology.¹ In Germany and in a number of Latin-American countries a similar situation obtains.

It is apparent, therefore, that in classifying a country as metric or English, as was done in Part I, Chapter III, on the basis of the predominant use of one system of weights and measures or another, no conception is given of how widely the prevailing system is used in various specialized fields in the country in question. The fact that the metric system is extensively used in the fields of science and domestic trade might be sufficient to put the country into the metric column. From a national standpoint such a classification might be complete enough, but it would not be so from the standpoint of the various fields of industry concerned. Especially is this true with respect to those fields that have persistently opposed efforts to force them to give up their customary weights and measures. The whole question of weights and measures as applied to special fields is the more significant when it is realized that there has been practically no *voluntary* change from the older to the metric system outside of scientific pursuits.

Industrial Reasons for Persistence of Old Customs

The reasons for the continuance of old customs, especially in the basic industries of agriculture, mining, and manufacturing, in spite of compulsory metric laws, are in general the following:

1. Industrial fields have their own special interests and needs with respect to weights and measures and many of them have

¹ See p. 75.

long ago worked out practices specially suited to them. In a number of special fields the effort toward national unification on the basis of an entirely new system would appear to offer little advantage, if any, over the older units used.

2. The difficulty and cost of forcing a new system upon a given field might probably be greater than any benefit which could be derived from the complete unification of the nation on the basis of that system. In such a field as agriculture, for example, crops have been weighed and measured in certain customary ways for many years, and it becomes a problem indeed to induce the farmer to change this habitual procedure, which is entirely satisfactory to him, for another in which he can see no gain. The result is that he continues in his old habits, and the distributor must make the necessary adjustments to the new system in order to transact business in the legal way. Fields that are remote from the everyday processes of trade intercourse and from international markets are the ones in which the greatest difficulty in a change in systems is experienced. Other fields in which a change would be especially resisted are those in which it is necessary to maintain standards and practices relating to the interchangeability and replacement of parts of machinery. Such standards and practices, built up through years of effort, would have to be greatly altered in a change to another system of weights and measures.

3. The influence of trade has a double bearing. In one sense, as a market widens it makes for greater national uniformity in weights and measures. In another sense the direct opposite is true.

In a purely local market the customary units presumably fill local requirements regardless of intrinsic merits. As the scope of the market widens, however, the need arises for a more extensive standardization of the units employed in a particular field, and where a field has a world market, international standardization would naturally facilitate the spread of certain products and the ease with which they can be handled. In international commerce the question of the unit used depends largely upon the commercial importance of the country of origin or of destination. Often commercial dependence is shown in the regulations governing weights and measures used in the imports and exports of smaller countries.

On the other hand, trade influences may not make for either national or international uniformity in weights and measures, since one special field having a world market might develop its product in one system while another field might develop its product in another system. In fact it is conceivable that a number of different systems of weights and measures might thus take on international aspects and each lay claim to being the best system for use the world over. From this standpoint the effect of industrial

factors as influencing the sale of products in a particular field having a world market, is directly opposed to the influence of a national law making for national uniformity of weights and measures.

It may be said in general, therefore, that it is chiefly considerations of industrial and popular use and foreign and domestic trade development which make for the persistence of old units of weight and measure, in spite of compulsory laws to the contrary. Only in those fields in which industrial influences have little bearing and where there is a transcendent counter-influence making for a change in weights and measures, is any change brought about without great difficulty.

Feasibility of Changing Weights and Measures in Special Fields

Two general considerations are to be taken into account in discussing a *change* in weights and measures in a given field. If a country is already either predominantly metric or predominantly English, the question of change, as applied to a particular field not using the prevailing system, might be viewed from the standpoint of completing national unification. On the other hand, the simplicity and logical structure of one system might commend itself to some fields, while the convenience and flexibility of another would appeal to other fields, so that, apart from the question of national uniformity, a given field would prefer the system of weights and measures best fitted to its needs.

In short, the special needs of particular fields must be taken into consideration in evaluating the desirability or feasibility of a change in weights and measures in any country. This is especially true in the United States where the English system has been so thoroughly unified and established.

In discussing a change in the United States, the needs and interests of specialized fields must be laid side by side, and the decision arrived at must reflect the interests of all groups and not those of a minority. It must be borne in mind also that it is not only the numbers in a group which determine its relative importance, but the magnitude of the interests affected must likewise be taken into consideration. In arriving at a properly weighted result, various special fields should be subjected to such questions as those bearing upon the origin and development of an industry; the importance of standardized practices in achieving and holding the position occupied by an industry; the scope of an industry, i. e., whether it is limited or broad; the manner in which weights and measures are tied up with the particular products made; the relative importance of one field of industry as against another; and the question of how great a demand exists in a given field for a change in weights and measures. Such questions might be elaborated as follows:

1. Has a given field had its origin and development in a certain country and then spread to the rest of the world, carrying with it the weights and measures of the country of origin, so that today the customary practice in that field the world over is universally in one or another system of weights and measures? An affirmative answer to this question is found, for example, in the textile cotton industry, in which the English system is in predominant use everywhere. A negative answer would be given in the wool industry, which is indigenous to many countries and has developed from no one center.

2. Does the position an industry has achieved and now holds center about standardized practices with respect to weights and measures, built up after years of effort, and would the destruction or alteration of these practices virtually mean the giving up of the prominent place held by the industry? An affirmative answer to this question might be given by many industries which hold a leading place because of their perfection and use of standardized and interchangeable machine parts. A negative answer might be given by the field of science, to which such a question would have little application.

3. Is the scope of a certain field limited and local, as in agriculture or mining, or essentially international, as in foreign trade, so that there exists from this standpoint either a very little or a great incentive making for the use of a uniform system of weights and measures the world over?

4. Are weights and measures written into the very fabric of the institutions, implements or records existing in a given field, as in the records of land measurement or in the linear measures that went into the construction of a building or in weighing scales or capacity measures of various kinds, so that it is impossible to change the units in use without affecting all such institutions, implements or records?

5. What is the relative importance of one field as against another when it comes to considering the question of giving preference to the interests of a wider group as compared with the interests of a smaller group?

6. How much demand, if any, exists in a given field for a change in the system of weights and measures used?

Answers to such questions, as applying to major fields of industry in the United States, will doubtless clarify the issue with respect to the practicability or feasibility of changing the weights and measures of the nation. These answers will also indicate why it is that in some fields, as in the textile industry or in science, the English system or the metric is used the world over, practically regardless of the system in predominant use in a particular country; why in other fields, as in land surveying, the system used follows national lines almost entirely; and why in still others, as in foreign trade, the system follows the flag.

The major fields of industry in the United States will be briefly outlined in the remaining pages of this chapter, after which, in succeeding chapters, a broad analysis of the most important fields as related to weights and measures will be undertaken.

MAJOR INDUSTRIES OF THE UNITED STATES

In order to present a picture of the specialized fields that are concerned with weights and measures, the table opposite has been prepared. This indicates the status of the various branches of industry in the United States, measured by the number of workers of ten years and over employed in 1910 and also by the total productive value in 1914 of the products of the basic industries of agriculture, mining and manufacturing. The value of products exported from the United States in 1914 is likewise indicated. Under each major industrial grouping, data for which is printed in heavy type, subordinate groups are also given.

The following table indicates that in 1910 there were in the United States about 38 million wage earners ten years of age and upward, engaged in gainful occupations in the various fields listed. The total population of the United States ten years of age and over in 1910 was about 71½ millions, so that the groupings included in the table present a comprehensive picture of the industrial activities of the nation. Furthermore it should be noted that the 71½ million people, as the traveling and buying public, are closely connected with the fields of transportation and trade. This aspect of the problem will be discussed in the chapter dealing with these fields.

Some of the fields listed in the following table have a decided interest in questions of weights and measures; other fields have very little interest. Weights and measures are used chiefly as a means of setting standards that can be readily understood in the manufacture, comparison and exchange of commodities. Since industrial and trade factors influencing the use of weights and measures are exceedingly important, such use in any particular field should be viewed from the standpoint of a product to be understood, evaluated and exchanged. As was pointed out, in some fields a change in systems would affect the products and in others it would not. On the other hand, while the product might remain unaffected by a change in systems, the processes and implements used to fabricate the product might be affected. Again, the greatest effect of a change might be neither upon the product nor the processes but upon the habits of the people associated with a given field. In short, besides considering the questions raised above,¹ in investigating the feasibility of a change in weights and measures special fields should be examined from the standpoint of the effect

¹ See p. 51.

TABLE I

MAJOR OCCUPATIONS AND INDUSTRIES OF THE UNITED STATES

Source: Reports of the Bureau of the Census, Department of Commerce

Occupation	Number Employed in Gainful Occupations ¹	Total Production for 1914 ² (Dollars)	Exports of the United States for 1914 ³ (Dollars)
Agriculture and Mining ..	13,624,027	13,442,298,242	787,940,087⁴
Agriculture, including forestry, animal husbandry and fishing	12,659,203	11,323,992,000	713,496,510
Mining	964,824	2,118,306,242	74,443,577
Manufacturing and Construction	10,658,881	24,246,434,724⁵	1,283,117,657
Transportation and Trade	6,252,341	.....	.....
Transportation	2,637,671	.....	.....
Trade	3,614,670	.....	.....
Retail dealers	1,195,029	.....	.....
Salesmen and saleswomen	921,130	.....	.....
Wholesalers, importers and exporters	51,048	.....	.....
All others	1,447,463	.....	.....
Professional	1,663,569	.....	.....
Science and engineering ..	139,298	.....	.....
Medicine and pharmacy ..	285,108	.....	.....
Teaching	614,905	.....	.....
Law	114,704	.....	.....
Ministry	118,018	.....	.....
Miscellaneous	391,536	.....	.....
Miscellaneous	5,968,518	.....	.....
Public Service	459,291	.....	.....
Domestic and personal service	3,772,174	.....	.....
Clerical occupations	1,737,053	.....	.....
Total	38,167,336	37,688,732,966	2,071,057,744

¹ Population 10 years of age and upward, census year 1910. Includes all male and female wage earners, proprietors and firm members, and salaried employees. "Statistical Abstract of the United States," 1920, Table No. 192, pp. 273-83.

² "Statistical Abstract of the United States," 1919, Tables No. 125 (Agricultural and animal husbandry products), No. 158 (Mineral products) and No. 158 (Manufactured products). "Statesman's Yearbook," 1916 (Forestry products). "Statesman's Yearbook," 1917 (Fishery products, as given for the last census of fisheries for 1908). Production has greatly increased since 1914. The total gross wealth produced on farms, for instance, increased from about \$10,000,000,000 in 1914 to about \$25,000,000,000 in 1919.

³ Exports of Domestic Merchandise, compiled from the "Statistical Abstract of the United States," 1920, Table No. 294.

⁴ Raw agricultural products and raw materials, including iron ore, coal, copper ore, nickel, zinc, asphaltum, graphite, stone and crude oil (mineral).

⁵ Includes products manufactured from raw materials imported from other countries.

of a change upon the products themselves, upon the processes by means of which the products are fabricated, and upon the habits of people involved either through the sale of the products or otherwise.

The fields of science and engineering are often mentioned as ones that would be favorably affected by a compulsory change to the metric system in the United States. As will be noted from the preceding table, these fields fall in the professional group and are in the main the only ones in that group intimately connected with the use of weights and measures. Law and the ministry are quite remote from any such use, but teaching would be concerned in a change of systems in so far as the change affected the difficulty of or the time required for instruction in the new system.

Agriculture and mining are industries having to do with raw materials, the nature and form of which are little affected by whatever use is made of weights and measures in these industries. The same observation may be made with respect to the fields of transportation and trade; activities of these fields have little effect upon the nature and form of the materials handled. For this reason the four fields are discussed together.

The field of manufacturing is preëminently concerned with the transformation of raw materials into finished products of a definite size, shape, capacity, or design. Through manufacturing processes weights and measures are embodied in the products fabricated, so that this field is of great importance where a change in weights and measures is under consideration. For this reason a separate chapter is devoted to a discussion of the field of manufacturing.

The field of foreign trade belongs logically under "trade," but since its connection with weights and measures is different from that of strictly domestic trade activities, it is likewise treated in a chapter by itself.

The various special fields, therefore, that will receive more detailed analysis in the following chapters with respect to their relation to weights and measures are the following: Science and engineering; agriculture, mining, transportation, and trade; manufacturing; and foreign trade.

CHAPTER VI

SCIENCE AND ENGINEERING

The professional field, as indicated in the preceding chapter, included in 1910 about one and one half millions of the productive population of the United States ten years of age and over. In this general field science and engineering have a very definite connection with weights and measures, and teaching has a remote one to be touched upon in Part III.¹

In 1910 those engaged in science and engineering numbered 139,298 and in medicine and pharmacy 285,108, altogether less than one-half million out of about thirty-eight million productive workers, or slightly more than one per cent of the whole. Including medicine and pharmacy with science and adding those industries built around minute measurements, scientific activities, even though thus amplified, encompass less than one per cent of the total productive population of the United States. The engineering field is still smaller. These figures furnish a rough estimate of the relative sizes of the fields under discussion.

In the fields covered in this chapter, as in those covered in later ones, only such aspects of their relation to weights and measures are dealt with as are commonly mentioned in current discussions of the question.

ANALYSIS OF FIELDS

With respect to their interest in weights and measures, scientists and engineers are not so closely akin as one might infer from the fact that the field of engineering is very largely associated with that of science.

Science

The metric system finds its widest scope in laboratory and pure science, where its use is very general. The system is eminently suited to scientific work because of the minuteness of measurement necessary in this field. In fact even the millimeter, the smallest unit of metric measure, is often too large for scientific purposes, and smaller units—the micron, which is one-thousandth

¹ See pp. 141-144.

part of the millimeter, and the millimicron, which is the thousandth part of a micron—have come into use.¹

Scientists in the United States, Great Britain, and Russia have for many years employed metric weights and measures in their daily work, although the English system is the standard for most other purposes in these countries.² In American college text books on physics and chemistry, the use of metric measures dates as far back as 1868.³ In metric countries in the field of science the use of the metric system is practically universal.

The fields of applied science most often mentioned in discussions of weights and measures are chemistry, medicine and pharmacy, and certain industries centering around minute measurements, which industries may be considered as more closely related to science than to other manufacturing fields.

Chemistry

The relation of chemistry to industry will be considered under the discussion of the chemical industry in Chapter VIII. Here it will be sufficient to state that chemists use the metric system almost exclusively in their laboratory work, to which it is apparently well suited. This is true even in the United States and Great Britain, but the generalization applies only to laboratory chemistry and not to manufacturing and commercial operations, in which the English system is almost exclusively used in English speaking countries. In this connection, Professor Eugene C. Bingham, of Lafayette College and Chairman of the Metric Committee of the American Chemical Society, writes: ⁴

American chemists are trained in the metric system and use it throughout, except where the usage of the English system by the community makes the use of metrics impracticable.

Recently the Institute of Chemistry in Great Britain reported that it favored the metric system, "although hesitating to state dogmatically that its immediate compulsory adoption would be in all respects advantageous."⁵

Medicine and Pharmacy

The science of medicine is closely connected with chemistry, physiology, biology, microscopy, and other sciences in which minute measurement plays an important part. In biological or medical research the metric system is used practically exclusively. In pathology the dimensions of organs are stated in centimeters or

¹ Hallock, W., and Wade, H. T. "Outlines of the Evolution of Weights and Measures and the Metric System," p. 140.

² *Ibid.*, p. 161.

³ *Ibid.*, p. 125.

⁴ Letter to N. I. C. B., June 14, 1921.

⁵ Great Britain. Metric Committee, Conjoint Board of Scientific Societies. Report on Compulsory Adoption of the Metric System in the United Kingdom, February, 1920, p. 59.

millimeters. The oculist employs the metric system in his measure of focal length.¹

In the practise of medicine and pharmacy in the United States the general trend seems to be toward the use of the metric system, but as one authority² observes, "while there is a growing tendency for doctors to use the metric system and a certain growing tendency on the part of the pharmacists to use metric weights and measures, only a slight advance has been made in this direction." The same authority expresses his conviction that the majority of practicing physicians do not use the metric system in writing prescriptions, and that a very large majority of the dispensing pharmacists of the country still adhere to the English system. He estimates that probably 75 per cent of the total number of pharmacists in the United States do not possess adequate metric weights and measures. The younger generation of pharmacists and physicians, he declares, become familiar with the metric system in college, but upon leaving find that it is easier to use the English system. Physicians, he continues, find their reference books written in terms of minims, grains, and drams, and also soon find that the average dispensing pharmacist is not equipped to fill prescriptions in the metric system.

In reply to questions regarding the use of the metric and English systems in the writing of physicians' prescriptions, the Vice-President of Louis K. Liggett Company, operating the Liggett chain of drug stores, quotes the company's prescription department head as follows:³

I took 1000 prescriptions in our files picked at random and covering a period of the last three years, and find that 17.4% were written in the metric system. Where the metric system is used by physicians of presumably American extraction, it appears to me as though in many instances the prescription was thought out in the English system and then translated into and written in the metric system. I find from our experience in the prescription departments that the habit of transferring quantities written in the metric system is like learning a new language; it will never be successfully employed until we are taught to think in the metric system and not simply translate.

In Russia, which is known as one of the countries in which the English system of weights and measures predominates, the metric system is generally used by doctors and pharmacists.

In Great Britain the Royal Society of Medicine, in commenting on a recent report of the British Metric Committee, stated that it "strongly endorses the proposal to adopt the metric system in

¹ Hallock, W., and Wade, H. T., *op. cit.*, p. 193. See also p. 60 of present report.

² Francis, Dr. J. M., Parke, Davis & Company, Detroit, Michigan, June 1, 1921 (Letter to N. I. C. B.). See also letters to N. I. C. B. from Superintendent St. Luke's Hospital, New York, June 8, 1921; Superintendent New York Post Graduate Hospital, June 4, 1921; Eli Lilly & Co., Indianapolis, June 6, 1921; J. C. Roberts, Sharp & Askine, Baltimore, June 11, 1921.

³ Letter to N. I. C. B., June 15, 1921.

connection with medical science."¹ The Royal College of Surgeons also signified its approval of the committee's report.

In France, however, although doctors and druggists use the gram as a basis, they measure in quantities corresponding to ounces, tablespoons, drachms, scruples, and grains. The druggists' price lists give quantities in units of 30, 125, 250, and 500 grams or cubic centimeters, that is, in quantities of approximately 1, 4, 8, and 16 ounces.

In short, there is probably a tendency towards the use of the metric system in medicine and pharmacy even in English countries, but no uniform procedure has yet been adopted in these fields in any country, much less the world over.

Industries Using Minute Measurements

Under this heading are included those industries most frequently mentioned in discussions regarding weights and measures, as having found the metric system well adapted to their work. Watchmaking and the making of optical instruments are examples.

Switzerland is generally regarded as the home of watchmaking. Here the *ligne*, and the *douzième ligne*, respectively $\frac{1}{12}$ and $\frac{1}{144}$ of the old French inch, together with special systems peculiar to individual manufacturers of certain parts, were originally used in the manufacture of watch movements. Today the metric system is generally used in the manufacture of Swiss watch movements,² although in the trade certain dimensions, such as the external dimensions of the assembled movements and the watch cases, are apparently still designated in the old *ligne* measurements.³ An effort is being made, however, to standardize the manufacture and designation of watches in the metric system, and those intimate with the industry in Switzerland and France express the belief that the old units will be eliminated shortly. Other European metric countries have had to rely on Switzerland in watchmaking and have followed her lead in the weights and measures used.

This is to some extent true also of the watchmaking industry in the United States, in that skilled workers from Switzerland aided in its establishment in this country and used here the same measurements they had used before. Some concerns, however, em-

¹ Great Britain. Metric Committee, Conjoint Board of Scientific Societies. Report on Compulsory Adoption of the Metric System in the United Kingdom, p. 64.

² Letter to N. I. C. B., June 10, 1921, from Dr. George F. Kunz of Tiffany & Co., New York. Letter to N. I. C. B., June 4, 1921, from De Forest Hulburd, Vice-President, Elgin Watch Company. Letter to N. I. C. B., June 13, 1921, from H. M. Groff, Chief Engineer, Ingersoll-Trenton Watch Factory. Letter to N. I. C. B., May 31, 1921, from E. A. Marsh, General Superintendent, Waltham Watch Company.

³ Director, Ecole Nationale D'Horlogerie to N. I. C. B., July 30, 1921, citing letter of Secretary Chambre Suisse De L'Horlogerie.

ployed English units and still do, so that there is no uniform practice in the United States.

The Ingersoll and Waltham watch companies, for example, use the metric system. The manager of the former company attributes the use of metric units to the fact that the drawings received from Switzerland were metric.¹ Mr. E. A. Marsh, General Superintendent of the Waltham Watch Company,² writing in 1903, had the following to say regarding the use of the metric system in his company:

We have employed the metric system of linear measures since about 1868, and for our factory purposes have found it very convenient. . . . The ordinary subdivisions of the standard inch are not sufficiently minute for our requirements. Previous to our adoption of the metric system we had constructed and used fine gauges indicating dimensions as fine as 1/2500 of an inch, but such a quantity was not simply expressed nor readily multiplied. In adopting the metric system we arbitrarily took as our standard unit, not the full meter but the centimeter, which we divided into tenths, hundredths, and thousandths. . . . Having adopted this system in the measurement of watch parts, it was not at all difficult to apply it in our machine shop. On this system we have been running an entire factory for nearly 35 years, with the exception of its application to shafting and pulleys which, to quite an extent, we purchase in the market.

On the other hand the Elgin Watch Company is among those concerns using the English system exclusively³ and the Ingersoll-Trenton Watch Factory uses both systems. The general situation in this country is well summarized in the following statement⁴ from H. M. Groff, Chief Engineer of the Ingersoll-Trenton Watch Factory.

In the case of the manufacture of watch parts, there are some factories employing English and others employing metric, while for watch cases, the prevailing practice seems to be English—although there are some cases where obsolete standards of measurements used in some foreign localities have been injected into case manufacturing here in the United States. . . . There are some companies where the metric system is used for dimensioning the watch parts, but English measurements are used throughout in the manufacture of special machines for producing these parts. The whole situation as far as a standard of measurement in the watch industry is concerned is in more or less of a confused state, due to the lack of any specific standard.

In this industry, as in others, there is evident need of a greater standardization of practice, either on the basis of the metric system, or on the basis of the English system, or on the basis of a combination of these systems.

¹ Sharpe, H. D., President Brown & Sharpe Co., Letter to N. I. C. B., April 13, 1921.

² Letter to F. J. Miller, New York City, February 9, 1903; confirmed by subsequent letter to N. I. C. B., May 31, 1921.

³ Letter to N. I. C. B. from Mr. De Forest Hulburd, Vice-President, Elgin Watch Company, June 4, 1921.

⁴ Letter to N. I. C. B., June 13, 1921.

Minute measures are used to a large extent in the manufacture of astronomical and other optical instruments. In Great Britain the English system is used in such work, as is indicated in the following quotation:¹

The established practise of British lense makers has generally been to manufacture lenses on the inch basis, but when selling them to metric countries to quote focal lengths and diameters in millimeters. . . . The standards of the British Engineering Standards Association applicable to optical instrument making . . . are practically all based upon inch measurements.

In the optical industry in the United States, however, most of the lenses are ground according to the metric system. Furthermore, the majority of other parts of the instruments made in the optical industry in this country are also made according to metric measures, although the English system is used too.² The following statement from the American Association of Wholesale Opticians, although, in the light of British experience, apparently biased in favor of the metric system, sums up the situation in this country.³

The metric system is absolutely essential and universally in use when it comes to the measuring of things ophthalmic and in the establishment of standards according to which optical lenses are gauged or measured. Years ago in the ophthalmic field when simple lenses only were used and before the advent of cylinder and compound lenses, the simple lenses (i.e., spheres) were gauged according to focal length in inches. With the event of compound lenses (i.e., spheres combined with cylinders) it was soon found that the old system of indicating lense strength was cumbersome and impracticable. The metric system was adopted for indicating the strengths of ophthalmic lenses. . . .

For a long time it was difficult for refractionists of the old school to adopt the new system. Tables of equivalents were in use for many years and lenses were marked according to both systems, but eventually the use of the metric system has developed so that now it is universally observed for indicating the focal lengths of all ophthalmic lenses.

For many years, even after the metric system became established for the use of focal length of lenses, the opticians and oculists still clung to the inch system of measurements for frames and mountings. . . . There has been a gradual increase in the use of the metric measurements for frames and mountings until today possibly 75 per cent of the prescriptions are written with the bridge measurements according to the metric system and possibly not more than 25 per cent written according to the inch system. There is no question at all but that within a few years the metric system will universally prevail in the optical trade and profession for indicating dimensions for spectacles and eye-glasses.

¹ Great Britain. Report of Department of Scientific and Industrial Research, representing the following organizations: The British Optical Instrument Manufacturers' Association; The British Admiralty; The British War Office; The British Air Ministry; The National Physical Laboratory; The Imperial College of Science and Technology.

² See United States. Hearings before House Committee on Coinage, Weights and Measures, February, 1902, pp. 84-88. Testimony of J. A. Brashear.

³ Letter to N. I. C. B., March 1, 1921.

Engineering

Since the engineering professions are closely related to science, it might be supposed that the metric system would be extensively used in the field of engineering. This is not true, however, because of the fact that engineering activities are carried on in connection with the practical work of manufacture and it is necessary for the engineer to adapt his work to the requirements of the manufacturing field. Some of the most determined opposition to the metric system has come from the engineering professions.

The most important engineering fields concerned with the question of weights and measures are the electrical, mechanical, and civil. Under mechanical engineering the question of mechanical standards and their maintenance is an important one in considering a change from the English to the metric system, but since this question concerns chiefly certain specific manufacturing industries, a detailed discussion of it is reserved for the chapter on manufacturing. Under civil engineering emphasis is placed upon land measurements because of their important connection in any country with older systems of weights and measures.

Electrical Engineering

Practically all electrical engineers in France and Germany, both of which are metric countries, use the metric system. In Japan, a country employing the metric system to some extent, electrical engineers use the English system.¹

In 1893 an International Congress of Electricians was held in Chicago, and a Chamber of Delegates composed of officials appointed by the various governments named and defined various electrical units.² The deliberation of the Congress resulted in a series of recommendations which were referred to various nations of the world, by many of which they were subsequently embodied to a greater or less extent in legal enactments making the use of the new units obligatory in electrical practice. Such an act was passed and approved in the United States, July 12, 1894.

It appears, however, that in electrical practice the world over there is as yet very little uniformity or strict adherence to one system of weights and measures rather than another. A committee of the American Society of Mechanical Engineers tersely summarizes this phase of the matter as follows:³

Electrical engineers are said to be largely using the metric system. They are in fact using a mongrel system, comprising the C. G. S., or absolute system, the metric system with the centimeter instead of

¹ R. W. Horne Company, Tokyo, Japan. Letter to Henry R. Towne.

² Hallock, W., and Wade, H. T., *op. cit.*, p. 208.

³ Report No. 972, p. 685.

the millimeter as the unit, English feet, inches and square inches, and several different wire gauges. In a pamphlet on dynamo design recently published are found the following:

Lengths, thicknesses, etc., 34.9, 20.85, 0.05, 0.706 and 1.16 centimeters.

Speeds, 1,300 and 1,735 centimeters per second, 3,500 feet per minute, 50 feet per second.

Areas, 3,242 square centimeters, 2.2 watts per square inch (= 0.341 watts per square centimeter), 600 circular mils per ampere.

Volume, 3,880 cubic centimeters.

Resistance of 1 centimeter of No. 6 B. W. G.

Lines of force, 7,800 per square centimeter.

While electrical theory and the science of electrical engineering is marked largely by the use of units derived from the metric system, on the industrial side the English system is in predominant use in practically all English countries.¹ On the whole, in the United States there appears to be a tendency to favor the metric system for certain fields of electrical science, but in practical work there appears to be just as strong a tendency to adhere to the units of the English system. The sentiments of electrical engineers in this country are quite divided regarding a change in systems, but even those favoring the metric system are in the main opposed to a *compulsory* change.²

Mechanical Engineering

The application of weights and measures to the field of mechanical engineering involves largely the question of the mechanical standards that have been adopted in the manufacturing industries of the United States. By mechanical standards are meant, first, profiles, dimensions, weights, sizes, etc., used by manufacturers for particular products to obtain interchangeability of parts that function together, such as pipe threads, screw threads, air hose couplings, track gauges, bolt heads, and nuts; and secondly, the series of dimensions, capacities, weights, etc., by which products are designated when placed on the market or used in further manufacturing operations, examples of which include pipe, bolt and nail sizes, yarn numbers, textile widths and weights.

A more detailed discussion of the subject of standards will be reserved for the chapter on manufacturing.³ At this point it will be sufficient to state that the mechanical standards used in the United States and Great Britain are all English and that these standards are in predominant use the world over. Regarding screw threads, for example, it is estimated⁴ that 80 per cent of those used the world over are made in the English system. France and

¹ Replies to the Board's questionnaire on the use of the metric system in various industries indicate that in only a very small portion of electrical manufacturing plants in the United States is the metric system used, and then chiefly only in specialized and limited connections.

² See p. 195 of present report; also United States. Hearings before House Committee on Coinage, Weights and Measures, Feb. 6, 1902, pp. 2-4 ff; also Hearings of 58th Congress, First and Second Sessions, pp. 150, 151, 185, 186.

³ See p. 83 ff of present report.

⁴ American Screw Thread Commission, 1919.

Italy are the only two countries using the metric system to any extent for screw threads.

The American Society of Mechanical Engineers has gone on record as opposing the compulsory adoption of the metric system.¹ Some mechanical engineers in England and the United States use the metric system but they are exceptions. In mechanical drafting few drawings in the United States are made to the metric scale, although the inch is often decimalized in drafting practice.

Civil Engineering—Land Measurements

The relation of weights and measures to civil engineering involves the building of railroads and of highways and the surveying and measuring of land, records of which are made, preserved and verified from time to time by further surveys.

The question of land measurement is of first importance in its bearing on a change from one system of weights and measures to another. Every state, every city, every plot of land is involved. A change would mean that land records would have to be revised to conform to the new standards, and the difficulty of making such revisions has been reflected in provisions of most compulsory metric laws exempting land measurements from their operation. In Denmark, for instance, where the metric system was made compulsory in 1910, the use of old land measurements is permitted until 1925.² In Uruguay the old measures reduced to metric equivalents are permitted in documents pertaining to real estate, the last survey of which was made prior to 1894.³ In Hungary measurements of land areas are the exception to the compulsory use of the metric system.⁴ In Brazil, where the metric system is used for most purposes, agricultural lands are generally divided into *alquieres* of 2.42 hectares each.⁵ Both metric and English scales are used in Japan.⁶ In Cuba, surveyors use the metric system in public and private surveys, but records are made in both metric and Spanish units.⁷ In Costa Rica the people generally use Spanish measures in their land transactions, although the registry of documents in the government office is made in meters and hectares.⁸ Official documents in Spain give both metric terms and their equivalents in old local units.⁹ These instances are typical of the situation the world over.

¹ Cf. Fred. J. Miller, President American Society of Mechanical Engineers. Letter to the President of the Society of Civil Engineers of France, Feb. 10, 1920.

² See Part I, p. 22.

³ See Part I, p. 27.

⁴ See Part I, p. 23.

⁵ Hoover, C. L., United States Consul, Sao Paulo, Brazil. Letter to *American Machinist*, March 13, 1917.

⁶ Hallock, W., and Wade, H. T., *op. cit.*, p. 93.

⁷ Holladay, R. E., United States Consul, Santiago, Cuba, March 30, 1904. Letter cited in "Plain Facts," Pamphlet, National Association of Manufacturers, p. 30.

⁸ Cullen, C. P., Limon, Costa Rica. Letter to American Institute of Weights and Measures, Feb. 18, 1918.

⁹ Bowron, Joseph, United States Consul, Carthagena, Spain. Letter cited in "Plain Facts," Pamphlet, National Association of Manufacturers, Feb. 10, 1904, p. 41.

In the recent report of a British committee¹ it was recognized that certain English measures for land are not essential for surveyors' use, and it was recommended that the pole, the furlong and the league be abolished, that the use of the link and chain be limited to determining area, and that distance be expressed in miles or in decimals of a foot. Investigation has not given any indication of a demand for a change to the metric system either on the part of individual civil engineers or associations in Great Britain. In the United States the history of the Mississippi Valley, like that of Louisiana, Texas and other states, affords a practical illustration of the difficulty of substituting one system of land measurement for another. The early French settlers in the vicinity of St. Louis laid out their land in *arpents*, an old French unit of measure. This old unit has been retained in that section to such an extent that there is today scarcely any real estate not measured by *arpents*. The land at first was so sold and the unit still lingers in the speech and customs of the people. Its retention, under the circumstances, is also something more than a matter of habit or use. It is because real estate transactions are matters of permanent record, and permanent records are changed with great difficulty. To change them involves translations, tedious computations, and alterations of original records, and it opens the door to mistakes and fraud. In spite of such local practices in the United States, however, lands purchased from the public domain are today uniformly described in a simple decimal system of acres measured by square chains and decimal parts thereof, and urban real estate is usually laid off in "lots" of even feet, generally even tens of feet, as 50, 60, 80, 100, etc.

From the preceding analysis it is evident that in the field of civil engineering, and especially in land measurements, little has been accomplished even in metric countries in the direction of suppressing the older measures used. Most countries, in adopting the metric system, have either specifically exempted land measurements or have not enforced the law in this particular field.

RELATION TO QUESTION OF CHANGE

Viewed in the light of the questions raised on pp. 52-54 in the preceding chapter as to the nature, fabrication, and sale of the products in a given field, the field of Science stands in a unique position. Science produces discoveries, inventions, scientific books, and the like. Its chief tool is laboratory experiment. Its "goods" are not offered for direct sale to the consuming public, but to the engineer or manufacturer. Its methods are ever-changing and whatever meets its needs better, be it a new system of weights and measures or anything else, it can quickly adopt. Its interests

¹ Metric Committee. Conjoint Board of Scientific Societies. Report on Compulsory Adoption of the Metric System in the United Kingdom, Feb., 1920.

are essentially international. The quicker it can exchange and receive new ideas regarding discoveries and inventions the world over, the better are its interests served. In short, scientists do not depend upon standardized products to maintain their place; weights and measures are not tied up with the results of their labors, and a change in systems can be and has been easily effected.

Scientists are strong in their advocacy of a change to the metric system. For those who do much experimental work which involves considerable computing and calculations, a system which follows closely our decimal system of arithmetic is considered by many the better system to use, even though for other uses it might not be so well adapted. Medicine and pharmacy require a minuteness of measurement to which the smaller units of the metric system are well suited. This is likewise true of the manufacture of small or delicate instruments and products such as watches, in which industries the millimeter (about $1/25$ as large as the inch) is regarded by some as a better basic measure to use, although many manufacturers of minute parts prefer the use of hundredths and thousandths of an inch.¹

In the engineering professions, however, a different situation obtains than in the field of pure science, in that the interests of the scientist and calculator must be weighed against the interests of the manufacturer, whom the problem affects in an entirely different way; i.e., the engineer must combine theoretical considerations with practical ones. The engineering professions in the United States are as a whole opposed to a compulsory change from the English to the metric system, although certain individual engineers favor it.

In brief, a considerable demand for a change in systems of weights and measures in the United States comes from the scientific group and from those engaged in the manufacture of refined instruments and products, but this sentiment is not shared very much by the engineering professions. The whole field of science and engineering, however, comprised in 1910 less than 450,000 in the United States. Including those engaged in the manufacture of refined instruments, the total was set as high as 500,000, or about 1 per cent of the total productive population of the United States in 1910. Even though this group were unanimously in favor of a change, its size is small as compared with such fields as agriculture, mining, manufacturing and trade, and it would suffer no hardship through a change, while these others would. From the standpoint of the nation as a whole, therefore, the needs and desires of scientists should, of course, not take precedence over larger groups and weightier interests.

¹ See p. 145 of present report.

CHAPTER VII

AGRICULTURE, MINING, TRANSPORTATION, AND TRADE

These four fields are discussed together in one chapter because in a general sense, as has been pointed out, their connection with weights and measures is similar. The products associated with these fields are taken either as the forces of nature form them or after the fabricating or manufacturing processes have been applied, so that, with respect to the products, the weights and measures used in agriculture, mining, transportation, or trade do not involve any additional change of form. In other respects, of course, as will be pointed out in detail, these fields perform differing functions, and the effect upon them of a change in systems of weights and measures is of importance.

It should be noted also that each of these fields is closely involved with other fields in which questions of weights and measures play a different rôle. Agriculture is becoming more and more connected with chemical research; mining with chemical and mining engineering; the field of transportation touches civil engineering in the building of new lines, manufacturing in the supply of equipment, and trade in the practices of shippers. The field of trade is affected also by the measures used in agriculture, mining and manufacturing.

As indicated in Chapter V, the fields of agriculture and mining in the United States are large. The number of workers ten years and upwards engaged in them in 1910 was over 13,500,000, and the value of the products was over \$13,000,000,000 in 1914. In transportation and trade over 6,000,000 workers over 10 years were employed in 1910, making a total in all four fields of about 20,000,000 productive workers out of 38,000,000, or 52 per cent of the total. In short, from the standpoint of the interests of the country as a whole and of the practicability of a change to the metric system, the size and importance of the fields covered in this chapter are much greater than those touched upon in the last chapter.

ANALYSIS OF FIELDS

The fields covered in this chapter fall logically into two groups—agriculture and mining on the one hand, and transportation and trade on the other.

Under agriculture are usually included farming, lumbering, stock raising and fishing, while mining comprehends all industries which relate to the extraction of minerals from the ground. These two fields of industry create consumable goods and raw products which are passed directly to the consumer or which must later be put into a finished state through the fabricating processes involved in the very important field of manufacturing to be discussed in the next chapter.

Transportation and trade perform different functions. They carry products, either in raw or finished state, from one point in the distributive process to another and exchange these products for a money value. In short, they represent service activities rather than strictly productive ones.

Agriculture

In a broad sense of the word, agriculture signifies the production of all plants and animals useful to man and includes such specialized activities as the production of fruits and vegetables, the raising of live stock, dairying, and bee-keeping, and the production of forest trees and their by-products. Fishing is likewise included here, although, strictly speaking, it occupies a field of its own. The chief raw materials produced by agriculture may be summarized as follows: cereals and other grains, hay, cotton, tobacco, vegetables, fruits, sugar-cane, wool, manure, milk, cream, butter, eggs, meats and fowl, flowers, syrup, turpentine, timber, fire-wood and pulp-wood, fish and pearls.

Since the products of agriculture are fashioned by the laws of nature, which are largely beyond the control of man, it follows that they do not fall into any standard sizes or shapes with respect to weights and measures and that they must be secured by whatever processes are best adapted for the purpose. These processes and methods of production will vary according to whether, for example, one is cutting hay, or casting a net to catch fish, or picking berries. In short, the specialized needs of the various fields of agriculture have long since brought about certain practices closely adapted to these natural needs, very generally associated with natural systems of weights and measures, and having little to do with an artificial system such as the metric.¹

¹ On the importance of weights and measures in agriculture see United States. Hearings before House Committee on Coinage, etc., 58th Congress, 2nd Session, pp. 277 ff. Testimony of W. N. Hayes, Assistant Secretary of Agriculture.

It is generally found that in countries in which the metric system has been adopted, the old units of weight and measure have been retained in agriculture probably as long as in any other field and in many sections of the metric world are still retained today. In some degree this is due to the difficulty of enforcing changes in isolated communities and also to the fact that farm products have, in the main, a local market. In addition, a large amount of agricultural products that are exported are consigned to countries in which the English system is in predominant use. The chief reason, however, why old natural units of weight and measure have been retained is probably the one stated in the preceding paragraph.

The persistence with which old measures have been retained in the agricultural communities of various countries, as well as the diversity of these measures, may be illustrated by a few specific cases. It is notable that in metric Europe, France among other countries still uses the *boisseau* (bushel) in certain provinces for measuring grain,¹ and also that the market prices of agricultural products in that country are frequently stated by newspapers in the old measures.² In Spain certain cereals are still sold by the *fanega* (1.6 bushels);³ this same measure is used also in figuring the yield of land in Hungary. In Switzerland the *muid* (5.18 bushels) is used for measuring corn, wheat, etc., and the *quartern* ($\frac{1}{4}$ peck) for potatoes, apples, etc. In Norway the old *korn-tonde* or corn measure has been adjusted to hold 140 liters and a half measure to hold 70 liters.⁴

Latin-American countries also show a retention of old measures as well as a diversity of measures in agriculture. In Mexico, for instance, the *carga* (300 lbs.) is used in market quotations and in commercial transactions for corn and certain other farm products,⁵ and hay or straw is measured in *arrobas* (25 lbs.).⁶ Generally speaking, agricultural products in Brazil are quoted in wholesale trade in *arrobas*, but are sold in bag lots, each bag weighing 60 kilos.⁷ To figure the yield of cultivated land the *fanega* (bushel) is used in Uruguay and in Argentina.⁸ In Chile many of the old Spanish terms are used among the agricultural population in the south, but in determining the quantity the actual weighing is done in scales marked in kilograms. In Chile as in the United States, a commodity may be sold by the bushel.⁹

¹ M. L. H. deL'Espee, French mining engineer, quoted in Halsey and Dale, "The Metric Fallacy," p. 34.

² Nicholson, Edward, "Men and Measures," p. 29.

³ Ball, John H., Barcelona, Spain, manufacturer of machine tools, cited in Halsey and Dale, "The Metric Fallacy," p. 53.

⁴ Hallock, W., and Wade, H. T., *op. cit.*, p. 96.

⁵ Canby, R. C., Journal of Franklin Institute, Nov., 1902. (Letter.)

⁶ Stewart, Francis R., United States Consul, Vera Cruz, Mexico, Feb. 21, 1918. Letter to American Institute of Weights and Measures.

⁷ *Decimal Educator*, Dec., 1919, p. 180.

⁸ D. Meyer & Cia., Bahia Blanca, Argentina, July 31, 1916. Letter to National City Bank, New York.

⁹ Voetter, T. W., United States Consul, Antofagasta, Chile, Jan. 31, 1917. Letter to American Machinist.

Not only are the weights and measures used in agriculture in various countries diverse, but there is little uniformity of procedure among agriculturists even in a given country, much less the world over. There is apparently decided need for standardizing methods and practices in this field as in many others, but such a need must not be confused with the need of uniformity of weights and measures. A *system* of weights and measures may be thoroughly standardized, as in the United States, while at the same time the *practices* of a given field may be in considerable need of standardization.

This situation, as applying to agriculture, is well depicted in the following quotation:

Practically all countries, in their efforts to secure statistics of a competent, impartial and trustworthy character, have adopted crop reporting systems of a more or less varied and complex nature. It is this diversity of method, coupled with the different systems of weights and measures at present in use by the different countries, which present to statisticians their greatest difficulties, when agricultural statistics relating to different countries are sought to be compared.

When it comes to international comparisons of yields and conditions the difficulties presented are numerous and troublesome. . . .

For instance, this is very clearly demonstrated by the fact that in many countries the final results of agricultural statistics are expressed in units of weight, while in others they are expressed in units of measure whose weight in some cases cannot be ascertained. Again, in the United States and Great Britain, American and English units are used, in many South American and European countries the metric system, while in other countries systems of measure which differ widely from both the English and metric systems are in use.

Another striking illustration of the want of homogeneity in expressing given results is the fact that in Argentina for the purpose of expressing the condition of crops the terms "bad," "regular," "good," and "very good" are used; in Sweden the condition is expressed in a descending and ascending scale from the numeral 5, which is used as a standard to express an excellent condition; in Germany the numeral 1 is used to express an excellent condition, 2 for good, and 3 for fair; in England and the United States the condition is expressed in percentages, 100 per cent representing an average or normal condition, while in other countries the condition of crops is generally expressed in such descriptive terms as "poor," "fair," "good," etc.¹

As regards the use of the metric system, however, apparently no demand has ever developed on the part of those in the agricultural field for its adoption. The old natural units which have been employed in almost every agricultural community throughout the world have evidently been adequate for the purposes of the farmer, and the very tenacity with which he has clung to these old units in other countries may be taken as an indication of the farmer's attitude toward the compulsory

¹ Frank G. Andrews, Chief Division of Crop Records, United States Department of Agriculture. Letter to N. I. C. B., June 1, 1921.

adoption of the metric system in the United States. The attitude of the American farmer was evidenced in replies to the Board's questionnaire inquiring into the matter. Two associations intimately connected with special branches of the agricultural field, the American Seed Trade Association and the International Apple Shipper's Association, testified to the lack of use of metric units and indicated a strong opposition to the suggested change in systems.

Mining

Mining involves the process of extracting minerals from the earth in the form of ores, liquids or gases. The various products may be summarized as follows: Gold, silver, iron, copper, and other metallic ores, chemical salts, coal, crude petroleum, oils, natural gas, clay, glass, salt, abrasives, graphite, and stone.

What has been said in the last section with respect to the laws of nature controlling production in agriculture is likewise true to some extent of the field of mining. A difference lies in the fact that minerals or liquids must be dug out of or extracted from the earth in a very crude form, to be later refined, while in agriculture most of the products are produced by nature ready for use.

A mining company is, as a rule, organized at a source remote from the region in which the mining operations are subsequently conducted, so that the weights and measures generally used are the national units of the country unless the mining operations are carried on by foreign companies, in which case the engineering practice of the operating company usually prevails. In countries where the mining industry has been long established the old units used by the native miners have persisted. Gold and silver, however, have a distinctly international market and are sold both in metric and English units.

A review of mining practice in various metric countries will illustrate these general observations. In Spain coal is sold by the *arroba* (25.36 lbs.), the *quintal* (101.44 lbs.) or *tonelada* (2028.8 lbs.), both the latter approximating respectively the English hundred-weight and ton;¹ in Brazil coal is quoted by the *para* (ton) and converted locally into 1,000 kilos or 40 cubic feet by measurement;² in Italy marble is measured by the cubic meter or the square meter when cut into slabs;³ in Uruguay stone is measured by the metric ton which approximates the English long ton;⁴ in Germany sales of potash are given in metric tons;⁵ in Mexico

¹ Ball, John H., Barcelona, Spain, manufacturer of machine tools, cited in Halsey and Dale, "Metric Fallacy," p. 53.

² Acting British Consul, Para, Brazil, 1919. *Decimal Educator*, Dec., 1919, p. 180.

³ Thomson, M. A., Marble Contractor, New York City.

⁴ Bonino & Schroeder, Montevideo, Uruguay, April 26, 1918. Letter to W. R. Grace and Co., New York.

⁵ United States, Bureau of Foreign and Domestic Commerce, *Commerce Reports*, January 4, 1921, p. 46.

English measures are used by American owners for smelting and smelter products, and the metric measures by Mexican owners.¹

In Cuba, Peru, Japan and South Africa, in which countries the metric system is either optional or compulsory for official use only, it is natural to suppose that miscellaneous weights and measures would be in use, and an examination shows this to be the case. In Cuba the metric system is used for mining except in transactions with the United States, in which case feet, inches, and pounds are used.² In Peru mine products are measured in *marcs* (228 grams), troy ounces, and grams; in mining, the hectare is invariably used for surface measures.³ In Japanese official statistics the *momme* is used for gold and silver, the French *tonne* for iron, the *kin* for copper, and English units for Korean products.⁴ In the mining districts of South Africa machinery and supplies are imported in various systems.⁵

In the mining industry of the United States, products are weighed and measured in the English system. In the processes and implements used in the extraction of minerals, the manufacturing field is involved, and since practically all mining tools are made by American manufacturers, English units are employed here too.

In the coal industry, for example, it is well known that the invariable custom is to measure and sell coal by the ton. In answer to the Board's questionnaire, the National Coal Association reported that, although it might not be extremely difficult to change from the tonnage basis to metric measure, there could be no benefit in such a change and that as far as repair parts to machinery, etc., is concerned a change would raise considerable objection. This without question represents the attitude of the mining industry of the United States regarding a change in systems.

Transportation

Transportation embraces activities, public and private, having to do with the carrying of goods or passengers by land or water. The term is applicable to teamsters, truckmen, and the like, as well as to express, telephone, railroad and steamboat companies and to the owners and masters of vessels. Transportation service itself has obviously no intrinsic connection with any particular system of weights and measures, although railroad rules, regulations and practices are closely bound up with the system used. Engineers, however, are concerned with the building of railroads and the design of transportation equipment; manufacturers are in-

¹ Brand, N. F., United States Consul, Salina Cruz, Mexico, Feb. 8, 1918. Letter to National City Bank, New York.

² Starbuck, C. B., United States Vice-Consul, Cienfuegos, Cuba, Feb. 27, 1918. Letter to American Institute of Weight and Measures.

³ Basadre, Carlos, Lima, Peru, December 26, 1916. Letter to *American Machinist*.

⁴ Letter from Tokyo representative of F. W. Horne Company to Henry R. Towne, April 13, 1918.

⁵ Hallock and Wade, *op. cit.*, pp. 155-156.

volved in the making of railroad supplies and equipment, and merchants with freight regulations. The system of weights and measures used in transportation is consequently related to all these fields.

Land Transportation. In land transportation the use of weights and measures is mainly in the calculation of mileage charges and freight rates. In metric countries, the metric system is generally used; in English countries the English system is employed.

In Latin America, for example, Colombia, Bolivia,¹ Mexico,² Uruguay,³ Venezuela,⁴ Brazil,⁵ Chile,⁶ Peru,⁷ and other countries use the metric units; first, in railway and highway construction; second, in recording railway and highway distances; third, in calculating freight tariffs; and fourth, in calculating fares. In these countries the railways are under government control, and since the metric system is the official system it is naturally used in all railway matters.

In countries using the English system in construction or similar work the mile, foot, or other English measure of length is used; freight tariffs are established usually on a ton or pound basis and fares are calculated according to the number of miles of travel.

Water Transportation. Weights and measures are related to water transportation in three ways: through the calculation of tonnage, through the calculation of tariffs and fares, and through the calculation of distances and in the making of nautical charts, tide tables, etc. The use of weights and measures is also involved in shipbuilding, but such use relates as much to the manufacturing field as to transportation itself.

The outstanding facts in water transportation are that the English nautical mile is the world's standard and ship tonnage the world over is usually expressed in English tons. This is due to the long-standing influence of Great Britain in maritime affairs and to the fact that the nautical mile equals one minute of arc of a great circle of the earth's circumference and has in consequence been found most convenient by mariners. When the metric system was devised an attempt was made to correlate the measurement of

¹ United States. Bureau of Foreign and Domestic Commerce, Special Agent Series 174, p. 141.

² Scholes, W. H., United States Consul, Nuevo Laredo, Mexico. Letter to American Institute of Weights and Measures, Jan. 25, 1918.

³ Reyuser y Taulmnat, Montevideo, Uruguay, July 31, 1916. Letter to National City Bank, New York.

⁴ Henry, F. A., United States Consul, Puerto Cabello, Venezuela, February 23, 1918. Letter to American Institute of Weights and Measures.

⁵ National City Bank of New York, Santos, Brazil, September 11, 1916. Letter to National City Bank, New York.

⁶ Voetter, T. W., United States Consul, Antofagasta, Chile, January 31, 1917. Letter to *American Machinist*.

⁷ Piura Agencies Co., Piura, Peru, April 9, 1918. Letter to W. R. Grace & Co., New York.

distances at sea with the rest of the system and with angular measures of the earth's surface. This necessitated the division of the day into ten hours and of the circle into 400 degrees. After a brief trial the enforcement of this plan was found impossible and it was soon abandoned. With the usual 360-degree division of the circle the relation of the kilometer to a minute of arc of the great circle of the earth is not integral and is so awkward that it is never used in navigation. In consequence provision is made in the laws of most metric countries permitting the use of the English nautical mile. The unit in which freight is measured and rates and tariffs calculated depends largely upon the nationality of the vessel, but the English ton is generally used notwithstanding. Nautical charts, tide tables, etc., are not standardized on any system throughout the world, both the metric and old units of various countries being used.¹

In Austria the English sea mile and ship ton are permitted as exceptions to the use of the metric system; in Hungary, the English nautical mile is legal; in Denmark, the measurement of ships is excluded from the operation of the metric law; in Holland, English tonnage measure in shipping is permitted as an exception to the metric law; in Germany, the metric system is used in all government shipbuilding but certain private yards are reported as using English measures;² in Argentina, in which the metric system is compulsory for general use, the English nautical mile is used to express distances at sea, the fathom to express depths of bays, etc., the English ton to express tonnage and displacement, and freight is expressed in English or metric units according to the nationality of the vessel. Among other Latin-American countries in which the metric system has been made compulsory for general use, may be cited Uruguay, in which the English nautical measures—foot, cable, and fathom—are used for shipping purposes;³ Venezuela, in which English units are used to some extent in maritime affairs;⁴ and Chile, in which the English mile is used in marine measurements to express distance, although the meter is employed in charts of bays, the metric ton for tonnage and displacement, and the meter and kilogram for freight.⁵

It is apparent from the foregoing survey that in land transportation considered from a world standpoint, weights and measures follow the system in predominant use in various countries, while in water transportation, the English nautical mile and ship ton are employed almost universally.

¹ United States. Hearings before House Committee on Coinage, etc., February, 1902, p. 28. Testimony of O. H. Tittman, Superintendent Coast and Geodetic Survey.

² Linnard, J. H., Naval Architect, United States Navy Dept., September 5, 1902. Letter cited in Halsey and Dale, *op. cit.*, p. 41.

³ Bonino & Schroeder, Montevideo, Uruguay, April 26, 1918. Letter to W. R. Grace & Co., New York.

⁴ Henry, F. A., United States Consul, Puerto Cabello, Venezuela, February 26, 1918. Letter to American Institute of Weights and Measures.

⁵ Banco Espanol de Chile, Antofagasta, Chile, August 18, 1918. Letter to National City Bank, New York.

Trade

Trade embraces the occupations of those who engage in commerce or business transactions of bargain and sale. In general there are four classes of tradesmen: namely, bankers, brokers, money lenders, and insurance companies; retail dealers; wholesale dealers; and importers and exporters.

In 1910 there were about $3\frac{1}{2}$ millions engaged in trade in the United States. About 6 per cent of this total were in the banking group which is concerned chiefly with money and credit transactions and has little to do with the question of weights and measures. Wholesalers, importers, and exporters, altogether, numbered only 51,048 or little more than 1 per cent of the total. There are more wholesalers than importers and exporters in the United States but neither group is relatively important in size. Exporting and importing will be taken up in the chapter on foreign trade, while the wholesale field will be touched upon in the present chapter together with retail trade, which comprises the largest group in the field of trade. In 1910 there were 1,195,029 retailers in the United States or 33 per cent of the total number engaged in the whole field.

Wholesale Trade. Wholesale trade, as just noted, comprises a relatively small field so far as the number engaged in it is concerned. It is of importance in the discussion of changes in weights and measures, however, because it is in this group that the legal requirements of metric countries regarding weights and measures have been in the main enforced. In wholesale trade, commodities are bought and sold in the large trade centers mainly, and the sale is often the subject of some contract or bill of sale, so that there is a direct opportunity for the enforcement of national regulations.

It was pointed out on page 48 that the effectiveness of compulsory legislation in metric countries begins with the use of the system in government departments (and this applies to transportation, where the agencies are under government operation), and reaches its limit in the field of trade, the basic industries of agriculture, mining and manufacture remaining practically unaffected. It is possible now to make the further observation that the successful enforcement of metric laws ends with the relatively small field of wholesale trade and that considerable difficulty has been experienced in securing enforcement in the large and comparatively extensive field of retail trade.

Retail Trade. In retail trade old units of weight and measure have persisted in spite of metric laws. In some cases the metric units have been adapted to old customs; in others, old units have been expressed in metric terms. In most metric countries the half-kilo, a unit approximating the pound, has been retained.

In France it is called the *livre*, in Germany the *pfund*, and in Latin America, the *libra*.

That there is considerable diversity in the weights and measures used in retail trade in European metric countries is indicated by the fact that in France the tradespeople outside Paris still use the old units in many districts, although in bills or business documents metric units are specified.¹ In Scandinavian countries common or old measures are used along with the metric measures among the traders and peasantry.² In Switzerland the old units have been retained in local trade, although in some instances they have apparently lost their real value and have become multiples of the metric units.

A similar situation obtains among tradespeople in Latin-American countries. In Venezuela, in which the metric system has been compulsory for general use since 1912, only metric scales are allowed, but goods are still retailed in the equivalents of old measures.³ In Chile, where the metric system has been compulsory since 1891, the *libra* (pound) is very frequently used in the purchase and selling of goods for daily consumption and the *vara* (yard) for dry goods, although the liter is used extensively in retail trade in liquids such as milk, oil, etc.⁴ In Costa Rica, the Spanish pound and the *vara* are used and the merchants in their ordinary transactions disregard the metric law almost entirely.⁵ The *vara* is nearly universal in Latin America for the sale of dry goods.

The field of retail trade constitutes another example of the adherence to older systems of weights and measures in special fields in countries where the metric system has been made compulsory. As is the case in the agricultural field, there appears to have been decided opposition in most, if not in all, countries on the part of the common tradespeople to the adoption of the metric system and a tendency to evade the law requiring its use.

RELATION TO QUESTION OF CHANGE

Weights and measures are not, as has been said, intrinsically bound up with the products of agriculture, mining, transportation and trade. In agriculture and mining the raw material is taken from the ground or from the farm and delivered in bulk for the purpose either of immediate consumption or of manufacture, so that weights and measures are used mainly as a matter of convenience in valuing such raw material. In transportation and

¹ Nicholson, Edward, "Men and Measures," p. 289.

² Kielland, S. M., "Proceedings Engineers' Society of Western New York, 1902.

³ Pardo, Rafael, Caracas, Venezuela, August 11, 1917. Letter to American Institute of Weights and Measures.

⁴ Coquimbo Agencies Company, Coquimbo, Chile, April 10, 1918. Letter to W. R. Grace & Co., New York.

⁵ Cullen, C. P., Limon, Costa Rica, February 18, 1918. Letter to American Institute of Weights and Measures.

trade the commodity is taken at whatever stage of the productive process it happens to be and moved from one point to another and sold. In short, the nature and form of the products involved in the four fields covered in this chapter are little affected by the application of weights and measures.

With respect to raw materials, weights and measures are involved in the *implements* of extraction and cultivation, in weighing and in capacity measuring, and in scientific laboratory research and experiment in connection with their extraction. In the moving of passengers and freight, weights and measures are employed in the transportation equipment used and in the engineering work of building new lines. In retail selling, they are used in the weighing scales or the capacity measures. The metallurgist's and the chemist's apparatus, the engineer's levels and rules, the miner's tools, the farmer's agricultural machinery, the woodsman's axe, the fisherman's net or boat, the freight car, the retailer's weighing scales—these implements are bound up with weights and measures, but the implements as such are the products of the manufacturing field, to be dealt with hereafter, and not of the fields examined in this chapter.

Regarding the question of a change to the metric system in the United States, it is obvious that such a change would have little effect upon the raw materials produced by the fields of agriculture and mining. Since these raw products are perfected in the main by the forces of nature and therefore do not lend themselves to practices except those which fit the peculiar natural needs of these fields, a change of systems would doubtless have the same effect or lack of effect in this country as it has had in other countries. That is to say, the customary procedure would continue in agriculture and mining just as before, in spite of any change in the national system of weights and measures. Practically no nation has undertaken to force standards of weights and measures upon these basic industries. In some countries they have been specifically exempted from the operation of the metric law, and in all countries old customs have persisted. As has been indicated, the weights and measures used in agriculture and mining are employed chiefly to facilitate the handling and the valuing of the raw products and do not constitute a part of the products themselves. The material effect of a change to the metric system in these fields would be the almost total destruction of the weighing and measuring implements used, which observation applies also to transportation and trade, and new implements would have to be supplied by the manufacturing industries.

The Traveling and Buying Public

There is another effect, however, that the change would have, which, as it pertains to transportation and retail trade particularly,

is of paramount importance. This would have to do with changing the habits of not only those engaged in these fields but also of those that constitute the traveling and buying public. In 1910 there were about 71,500,000 people in the United States ten years of age and over. Most of these in their everyday activities engage in traveling and in the retail purchasing of consumable goods. With trade practices as bearing on weights and measures changed by compulsory law, the habits of the entire buying and traveling public, as well as of those directly engaged in selling and transporting goods, would be affected.

In the United States a man buys a size fifteen collar; the housewife, a pound of butter or a yard of cloth. In a country in which the metric system is used in retail trade a man would have to call for his collar in terms of centimeters; the housewife would be forced to buy her butter in kilograms and her cloth in terms of meters. Generally speaking, the one method of purchase is as good as the other, since the designations used are of no intrinsic significance to the purchaser. The chief consideration here, however, is that the terminology employed should be familiar to both the buyer and the seller. In the United States if a man were asked whether he would rather call for his collars in inches or in centimeters, or a woman if she would rather get her butter in pounds or kilograms, there is no question as to what the average purchaser would prefer.

In the four fields treated in this chapter, such little demand as exists for a change to the metric system comes from those engaged in wholesale trade, who, as has been noted, comprise a very small group, comparatively speaking. There is practically no sentiment at all in favor of a change to be found in the other fields discussed.

CHAPTER VIII

MANUFACTURING

The manufacturing fields have a very important connection with weights and measures, quite different from that of the fields studied in the two preceding chapters. Manufacturing processes transform raw materials into finished products of a definite size, shape, capacity or design and in so doing interweave into the very fabric of the products themselves the weights and measures used.

For this reason the manufacturing fields are among the most important in the United States as regards the question of the possible effects of a change to the metric system. Furthermore, as noted in Chapter V, in 1910 there were over 10½ millions of people ten years of age and over, or 28 per cent of the productive population, engaged in these fields and the value of their products was over 24 billions of dollars in 1914.

Of the 10½ millions so engaged in 1910, seven millions were wage earners; the rest were proprietors, firm members, salaried employees, and independent artisans of one kind or another. On the basis of wage-earners alone, the table opposite has been prepared listing the important manufacturing industries in the United States in 1914. These are given in order of importance, estimated by the number of wage-earners and the value of the products. The last column, pertaining to exports, presents an interesting comparison which will be useful in examining the facts analyzed in the next chapter.

Textiles, Iron and Steel, and Food Products, are the first three manufacturing industries in the United States, although a difference of opinion may exist as to their order of importance. Lumber, Paper, Chemicals, and Leather come next, with others of lesser importance following these.

The seven industries just mentioned will first be briefly surveyed, after which the relation of the whole manufacturing field to a change to the metric system will be discussed.

ANALYSIS OF FIELDS

The term "manufacturing" signifies the "application of labor to crude materials, whereby they are transformed into a new and

TABLE II
MANUFACTURING: SUMMARY BY GENERAL GROUPS, 1914

(Source: Department of Commerce. Bureau of the Census, "Statistical Abstract of the United States," 1920, pp. 192-93.)

GROUPS ¹	WAGE-EARNERS ²		VALUE OF PRODUCTS		EXPORTS FROM THE UNITED STATES, 1914 ³
	Average Number	Per Cent. of Total	Amount (Dollars)	Per Cent. of Total	
Textiles	1,498,664	21.3	3,414,615,000	14.1	76,124,894
Iron and steel and their products ⁴ (including railroad shops)	1,426,960	20.3	3,775,762,000	15.6	201,269,470
Food and kindred products	496,234	7.1	4,816,709,000	19.9	261,409,685
Lumber and its remanufactures (including sawmills and furniture factories)	833,529	11.8	1,599,710,000	6.6	71,911,576
Paper and printing	452,900	6.4	1,456,046,000	6.0	21,301,310
Chemicals and allied products	299,569	4.3	2,001,634,000	8.3	264,761,313
Leather and its finished products ⁵	307,060	4.4	1,104,595,000	4.6	68,550,337
Metal and metal products ⁶ (other than iron and steel)	262,154	3.7	1,417,042,000	5.8	147,732,732
Vehicles for land transportation ⁷	263,076	3.7	1,034,497,000	4.3	45,984,860
Stone, clay and glass products	334,702	4.8	614,162,000	2.5	13,193,652
Miscellaneous industries ⁸	861,489	12.2	3,011,663,000	12.4	110,875,828
Total, all industries.....	7,036,337	100.0	24,246,435,000	100.0	1,283,117,657

¹ Following the classification of the United States Census of Manufactures, 1914.

² Excluding proprietors and firm members and salaried employees.

³ United States, Bureau of the Census, "Statistical Abstract of the United States," 1920, pp. 475-511, Table No. 294, "Domestic Merchandise Exported."

⁴ Excluding automobiles, railway cars and shipbuilding.

⁵ Including leather boots and shoes, but excluding rubber boots and shoes.

⁶ Including bronze, brass, copper, lead, gold, silver, etc.

⁷ Including automobiles and railway cars.

⁸ Including automobile tires and all rubber goods, liquors and beverages, tobacco manufactures, shipbuilding, and other miscellaneous manufactures.

different quality, shape, or form, having a distinctive name, character, or use." As has been indicated, the question of weights and measures is intimately associated with manufacturing processes and manufactured products. This relationship will be more clearly apparent after a general analysis of specific industries.

Textiles

The use of weights and measures in the field of textiles has to do with every textile process from the raw stock to the finished goods.¹ A relationship has been established between the length of yarns and their weight; and the yarn is numbered accordingly. With slight exceptions the English yard-pound is practically the single standard for numbering spun yarn of cotton, linen and jute the world over.²

The four main branches of the textile industry are cotton, wool, silk, and linen and jute; and the differing lengths of yarn skeins in these branches are indicated as follows:³

Wool	1600 yards
(varies in England)	
Cotton	840 "
Worsted	560 "
Linen	300 "

The development of cotton manufacturing took place in England after the invention of the cotton gin had made raw cotton a cheap staple. It was developed in the English system of weights and measures and spread throughout the world from England. In some cases, as in Germany, for example, men actually went from England to assist in the founding of the industry, and as it spread it naturally carried with it the English system of weights and measures. Today, with the single exception of France, where the meter and half-kilogram predominate in the industry, but where English measures are also employed, the yard and the pound are the sole standards wherever cotton cloth is manufactured. In France, however, although the official system for cotton spinning is based on a length of 1,000 meters and a weight of a half-kilogram (French pound),⁴ it should be noted that for linen, jute and hemp the English system is used.⁵

The wool industry, unlike the cotton, is indigenous to many countries and did not spread from a single center; it therefore usually developed in the local units of the country concerned.

¹ Sharpe, H. D. Letter to N. I. C. B., April 13, 1921.

² For detailed exposition of the status of weights and measures in the textile industries see: United States. Hearings before House Committee on Coinage, Weights and Measures, 58th Congress, First and Second Sessions; 59th Congress, First Session, 1904; also, Great Britain. Committee on Commercial and Industrial Policy, Minutes of Evidence on the Metric Question, 1917, Evidence 22, pp. 4-7, 9; also *idem.*, evidence of Mr. George Moores, *in toto*.

³ Simon, M. Edward, Paris Metric Congress, 1900, cited in Halsey and Dale, "Metric Fallacy," p. 150.

⁴ Lamoignon, Paul, "Traité Theoretique et Practique de Tisage," 1900, p. 58.

⁵ *Ibid.*, p. 63.

The silk industry is similar to the cotton industry in that it spread from a center. Its origin, so far as western countries are concerned, was in France and in the old French units of weight and measure. The industry therefore carried with it these old French units and they are today the basis of the industry even in England and the United States. The retention of the old French units in the silk industry in France, despite the prevalence of the metric system in the country, illustrates from a fresh angle the persistence of old customs in special fields.¹

A brief review of specific examples will indicate the hold which the English system has in the textile industry in metric Europe and Latin America, as well as in countries in which the English system is the standard. In Germany the English system of weights and measures is used for cotton, linen, jute, worsted and wool, although other units are also used.² In Spain the Catalonian system of numbering yarns is used—a weight of 1.1 *lliures* and a hank of 500 counts—a system only slightly different from the English.³ In the cotton industry in Brazil, which is the most extensively developed manufacturing industry in the country, the English units are used for spinning the cotton into yarn and also for numbering yarn.⁴ Machines for this industry are imported into Brazil almost entirely from England and the United States, and the widths of cloth made on them are usually measured in inches.⁵ In Colombia the English yarn counts⁶ and in Uruguay the “universal numbering as used in the United States” are employed in the cotton mills.⁷ A similar situation obtains in China and Japan.⁸

Replies to the Board's questionnaire inquiring into the extent of use of the metric system and its desirability in the textile industries in the United States, were received from the National Association of Cotton Manufacturers, the National Association of Wool Manufacturers and the National Association of Finishers of Cotton Fabrics, and also from manufacturing establishments, explaining the situation in these industries and their attitude toward a change to the metric system. The results of these replies are briefly summarized in the following paragraphs.

The National Association of Cotton Manufacturers reports that some years ago it gave much time and thought to the study of the

¹ Halsey, F. and Dale, S., “The Metric Fallacy,” pp. 160-161.

² Donant, Franz, “Methodik der Bimungslehre and Decomposition für Schaftsweberei” (cited in Halsey, F., and Dale, S., “The Metric Fallacy,” 1st ed., p. 26).

³ Riera, Emili, “Guia Practic pera la Filatura del Coto,” Barcelona, 1901.

⁴ Banco Hispano Agricola, correspondent, Bello Horizonte, Brazil, 1917. Letter to National City Bank, New York.

⁵ Haeberle, A. T., United States Consul General, Rio de Janeiro, Brazil. Letter in unpublished Consular Reports, United States Department of Commerce, Aug. 25, 1920.

⁶ Guyant, O. E., United States Consul, Barranquilla, Colombia, March 13, 1918. Letter to American Institute of Weights and Measures.

⁷ Bonino & Schroeder, Montevideo, Uruguay, April 26, 1918. Letter to American Institute of Weights and Measures.

⁸ Letter from F. W. Horne Company, Tokyo, to Henry R. Towne, April 15, 1918.

relative merits of the English and metric systems, and "reached a very decided conclusion in favor of the English system, for the reason that the compulsory adoption of the metric system would necessitate numerous and expensive changes in manufacturing processes."

The National Association of Wool Manufacturers reported that the use of the metric system in woolen and worsted manufacture in this country is negligible, that there is no outstanding advantage in the use of metric units so far as domestic trade is concerned and that foreign trade is so small a part of the total business that "compulsory adoption would be highly undesirable." The Association further stated:

We cannot speak definitely for the industry, but should say that it probably does not favor compulsory change and think active opposition could be counted on quite confidently.

The Executive Committee of the National Association of Finishers of Cotton Fabrics recommended to a general meeting of the Association that

... it was the sense of the meeting that, so far as the finishing industry is concerned, the present system of weights and measures is satisfactory and at the present there is nothing to be gained by continued effort to change that system.

The report and recommendation of the Executive Committee was unanimously approved and adopted as the action of the Association at its meeting held March 8, 1921.

An establishment manufacturing suspenders reported that the metric system was seldom used in the plant and that no advantages in using that system were apparent in the business, which is standardized to some extent in English units, although not standardized internationally on that basis. This plant further stated that:

The change to the metric system would be a tremendously difficult job. All drawings would have to be changed, all jigs in the shop would have to be remarked, all scales and micrometers, etc., would have to be discarded and new ones substituted, all sample boards, etc., changed. In addition to this, it would cause endless confusion in connection with shafting fits, etc., and would cause much confusion in connection with supply orders and the like. These changes would require corresponding changes in shop processes to a great extent.

One establishment, manufacturing textile machinery,¹ made the following statement regarding the use of the metric system, first in the manufacture of textile machinery in the United States, and secondly in the textile industry itself:

The only place in the textile industry where the metric system is used is in adjusting and adapting certain types of machines to meet

¹ Curtis and Marble, Worcester, Mass. Letter to Associated Industries of Massachusetts, Feb. 17, 1921.

metric sizes in use in foreign countries. About one in five hundred of the machines for folding cloth is made for measuring a meter.

If the word industry refers to the textile industry as a whole the answer would be somewhat different. We do not know of any fabric made in this country that is built up on the metric units, nor do we know of any use of the metric unit except in the laboratory, or in the weighing out of certain dyes, and in a few formulæ, used in the silk industry, which are copied from the French and German.

In brief, the English yard-pound predominates in textile manufacture the world over and the industry in the United States is decidedly opposed to a change in systems.

Metal Products¹

The use of weights and measures in the manufacture of iron and steel products is involved in the buying of raw material, the making of specifications and drawings, and the manufacture of the product. Such products include structural steel, sheet iron, wire, hardware and tools, pipe, machinery, etc.

The metal manufacturing industry is most highly developed in the United States and Great Britain and metal products exported to foreign countries have in most cases been accepted as they were made—to English measurements. As a result the standards for machinery and machine parts which have developed in this industry have practically all been developed in the English system. Today these standards prevail universally throughout the English-speaking countries, very generally throughout Latin America and, to a large extent, also in Europe.

The prevalence of English standards in machine practice, even in metric countries, is well illustrated by Mexico.² The Superintendent of Machinery of the Mexican Central Railroad stated that the drawings of locomotives and cars and shop tools are all in English measurements—that, so far as he is informed, this is the case with all Mexican railways.³ It is further reported that all the railroads use English measures entirely in shop measurements, gauges, drawings of locomotives, cars and other apparatus. One manufacturing firm reported using metric measures in its designs and to calculate strain of materials, but English measures for sizes and dimensions of materials, lathe work, etc.⁴ All pipes for water, gas, etc., used in Mexico come principally from the United States and therefore carry English measurements, although when cut to length the meter is used.⁵

¹ Including iron and steel products only.

² Canby, R. C., Letter to *Journal of Franklin Institute*, November, 1902.

³ Johnson, Ben., October 7, 1902. Letter to F. A. Halsey cited in Halsey, *op. cit.*, p. 55.

⁴ Johnson, B., Superintendent of Machinery, Mexican Central Railway. Letter to *Engineering and Mining Journal*, September 9, 1905, p. 455.

⁵ Chapman, W. E., United States Consul, Mazatlan, Sinaloa, Mexico, March 14, 1918. Letter to American Institute of Weights and Measures.

The situation is similar in other Latin-American countries. According to reports, nails, screws, horseshoes, etc., used in Colombia are imported from the United States or England and are sold by the English pound or *arroba* of 25 English pounds. The English inch is used in machine shops in Colombia.¹ In the machine shops of Uruguay the meter and its divisions are supposed to be used, but as a matter of fact, following the general custom, the English inch is used.² Pipe sizes are in English measures, but in official and public documents these are reduced to centimeters.³ The foundries and machine shops of Brazil use both the English and metric measures because of the fact that mechanical devices, iron screws, etc., are for the most part imported from England and the United States.⁴ In Argentina the metric system chiefly is used for machinery, but the fact that a great quantity of this is imported from England and North America necessitates familiarity on the part of traders with the English inch. It is reported, also, that the pipe sizes used in sewer and soil pipe systems are given in meters but that gas and water pipe sizes are given in inches.⁵ In mechanical work in Venezuela, English units are generally used, especially in conjunction with machinery purchased abroad.⁶ In machine shops in Chile it may be said that up to the present the foot and inch have predominated. This is due to the fact that most of the machinery that has been in use has been imported from England. In making repairs to this machinery the English units have been used. Some machinery in use in Chile, however, has been made in France, Belgium, and Germany to metric dimensions, so that repairs are made in these dimensions also.⁷ In Peru the English system chiefly is used in machine shops, though repairs and replacements for European built machinery are handled in the metric system.⁸

It is claimed in general ⁹ that 39.3% of the machine tools used in South America are of American make, 43.2% British, and the remaining 17.5% of German, Belgian, and French make. This condition, of course, has considerable influence on the weights and measures used in the machinery trade in South America.

¹ United Fruit Co., Charles W. Sinners, Manager, Santa Marta, Colombia, February 5, 1918. Letter to United Fruit Co., New York.

² C. Perez Montolio y Cia., Montevideo, Uruguay, December 18, 1916. Letter to *American Machinist*.

³ Bonino & Schroeder, Montevideo, Uruguay, April 26, 1918. Letter to W. R. Grace & Co., New York.

⁴ Tilles, Silva, Chief Municipal Engineer, Santos, Brazil, Dec. 14, 1916. Letter to *American Machinist*.

⁵ Buenos Aires Branch, National City Bank, August 22, 1916. Letter to New York Branch.

⁶ Henry, F. A., United States Consul, Puerto Cabello, Venezuela, April 13, 1918. Letter to American Institute of Weights and Measures.

⁷ Voetter, T. W., United States Consul, Antofagasta, Chile, January 31, 1917. Letter to *American Machinist*.

⁸ Dasso, D., Callao, Peru. Letter to *American Machinist*.

⁹ Hood, O. P., Commissioner for *American Machinist*.

The prevalence of English standards is noted to some extent also in metric Europe, as is illustrated by the fact that in Germany, where the metric system is most generally used in the larger manufacturing centers, millimeters and inches are often used in the same shop and sometimes on the same piece.¹ Machines designed in Berlin and figured in millimeters are reported to have drill and tap holes marked in inches.²

Not only do English machine standards predominate the world over but the practices of the American and British machine industries have become more highly standardized than the practices of other special fields. This is well known with respect to pipe and other fittings and screw threads. It is true also of larger pieces of machinery, such as steam engines³ and boilers.⁴ The degree of standardization thus reached would be seriously affected by the discarding of the inch, which, with its decimal and binary subdivisions, constitutes the basis for present English machine standards.

In the United States it has become a general custom among engineers and machinists to work in hundredths and thousandths of inches, the practice being followed from draughting room to shop. Most outside dimensions are given in ordinary fractions, the tolerances being given in decimals. This practice involves the expression of all quantities in terms of a single unit, such as the inch, with the appropriate decimal fraction, and goes hand in hand with the increasing use of calipers and gauges decimally divided.⁵ There are a number of gauges for wire and sheet metal which state the thickness in decimal fractions of inches, sometimes to five or six decimal places. A standard gauge for sheet and plate iron and steel was established by Congress (Act of March 3, 1893) and the numbers defined in both inches and millimeters. The present tendency is to abandon all arbitrary gauges and to work to decimal parts of an inch, using a micrometer caliper.⁶

Replies to the Board's questionnaire on the weights and measures situation in American industry were received, among others, from the foundry and the machine manufacturing industries. Four foundry associations, and 173 individual concerns, most of them members of the National Founders Association, answered. The foundry associations were the American Foundrymen's Association, the National Founders' Association, the American Malleable Castings Association and the American Boiler Manufacturers'

¹ Hess, H., *American Machinist*, May 3, 1900.

² United States, Hearings before the House Committee on Coinage, Weights and Measures on the Metric Question, 1902, p. 4. Letter of Mr. A. H. Moore.

³ F. Fosdick, of Fitchburg, Steam Engine Company. Letter to Associated Industries of Massachusetts, Feb. 15, 1921.

⁴ Secretary of American Boiler Manufacturers' Association. Letter to N. I. C. B., Feb. 11, 1921.

⁵ Hallock, W., and Wade, H. T., *op. cit.*, p. 180.

⁶ *Ibid.*, p. 177.

Association. This group of manufacturers and associations may be taken as representative of the industry, since the plants are widely distributed throughout the eastern, southern and central parts of the country. The answers to the questions indicate in general a strong opposition to the adoption of the metric system in the foundry industry.

The replies testify that the metric system is very little used in the foundries of the country, and where used it is usually only in mechanical drawings, chemical laboratories and foreign specifications. It is indicated also that there is nothing inherent in the character of the product to make the metric system advantageous. More specifically, of the 173 establishments submitting replies, 155 or about 90 per cent of the total reported the industry as opposed to the compulsory adoption of the metric system. Only 16 plants were reported as favoring its adoption, eight of the 16 favoring it only if the metric system became general and universal and three more favoring it but strongly opposing the compulsory feature, believing its use should be optional and that it should gradually be substituted for the English system.

Regarding the situation in the metal products and machinery manufacturing industry in relation to the use of the metric system, the editor of the *American Machinist*, the Hydraulic Society and the National Machine Tool Builders Association, together with 107 metal and machinery manufacturers throughout the eastern, southern and central parts of the country gave the Board information. The editor of the *American Machinist*, a periodical published in New York City, says:

So far as we know, only one relatively small shop is now using the metric system. . . . There is absolutely no desire for the use of the metric system in the industry in general. . . . Considerable standardization work has been done in the English system, particularly as regards threads, tapers, etc.; and commissions are at work looking to the standardization of the parts mentioned and many others, in England and this country. . . . Standardization is desired for certain smaller parts, but, so far as we have been able to ascertain, the use of English sizes in machine tools has never been a serious hindrance to their sale in countries ostensibly on the metric basis.

The Hydraulic Society, stating that it expressed the sentiment of the entire industry, reported that the metric system is not used, that there is no desire for its use and that the industry is opposed to its compulsory adoption. The hydraulic industry, the Society says, is standardized on the English system in this country and there is a desire for the standardization of the industry the world over. The use of the metric system, it says, would aid the sale of the products in no way and would cause great difficulty and expense in changing, requiring considerable alteration in the processing of the product. The General Manager

of the National Tool Builders' Association reported that the metric system was used very little by the members of the association and that its use was considered very undesirable and would aid the industry in no way. The views of these three organizations are borne out in the main by the opinions of 105 of the 107 machine establishments reporting. Two plants, one manufacturing magnetos and the other machinery, reported that the metric system was used in their entire plants, that it was very desirable for such products, and that they were very much in favor of the adoption of the metric system. A third plant reported that it furnished machines in both systems but was opposed to a change to the metric system. The other 104 establishments, however, reported that the metric system was little used in their plants outside of a few specialized operations and that they were decidedly opposed to its general adoption.

The situation in the machine and foundry industries, therefore, is that they have already become highly standardized on the basis of the inch, that for machine purposes the decimalization of the inch is being increasingly resorted to, that English machine standards predominate to a marked degree the world over, and that there is a decided opposition in these industries to a change to the metric system in the United States.

Food Products

Weights and measures are related to the manufacture of food products chiefly in the processes of packing and labeling. In the main they follow the legal requirements of the country of manufacture, although many instances of the use of old local measures are to be found. For example, a large proportion of the food products of the United States and Great Britain is sold in foreign markets, and such sales have generally involved English weights and measures. This is especially true where food products are put up in packages or cans that weigh or measure an integral amount in the units of the country of manufacture. The tendency among canners of food products in the United States is to place English measures or weights and their metric equivalents on the can labels, which practice entails no hardship and facilitates foreign trade.¹

The situation in the metric countries of Latin America, which obtain a large proportion of their imports from the United States, will illustrate these observations. In Mexico canned and manufactured goods are imported from the United States, and where retailed in the original packages the English terminology is employed; when sold in bulk the kilo is used.² In Argentina, Eng-

¹ Secretary National Canners' Association, Feb. 14, 1921. Letter to N. I. C. B.

² United States Consulate, Tobasco, Mexico, Jan. 16, 1918. Letter to American Institute of Weights and Measures.

lish, American and some Dutch package and bottled goods are sold as packed, i. e., by the pound.¹ In Chile food products are sold at retail chiefly by the kilo or the Spanish pound, and at wholesale by the *arroba* (10 kilograms) and the *quintal* (metric quintal, 100 kilograms; Spanish quintal, 46 kilograms).² In Venezuela the *quintal* of 100 Spanish pounds, equivalent to 101.4 English pounds, was formerly much employed in the sale of coffee, cocoa and other products, and this usage still survives, although the transactions are officially reported as "per 46 kilos."³ In Uruguay a decree of February 8, 1918, provided that where merchandise is sold in sealed wrapping—cans, boxes, packages, bottles, demijohns, etc.—the net contents or weight (in metric units) must be indicated on the wrapping in an easily visible manner.⁴ In Brazil tinned goods and preserves from England and America bear English weights, but similar national products are marketed by metric weights.⁵

With respect to the situation in the United States and the attitude of the food products industry to a change in systems, replies received to the Board's questionnaire indicate similar conditions to those of other manufacturing fields. The answer of the Millers' National Federation through its secretary is typical. The secretary stated that the English system is used throughout his branch of the industry and that the Federation is opposed to the adoption of the metric system. He indicated, however, that there is considerable room for improvement in the packing of flour, in that today the basis is still the barrel of 196 pounds, and that the Federation favors some decimal multiple instead. This, he continued, should be arranged for in the English system, but a change to the metric would be absolutely impracticable and of no advantage.

Lumber

The use of weights and measures in the lumber trade involves in the main indicating the thickness and width of the boards. The cutting of timber and the sawing into boards is indigenous to many countries and a great diversity exists in the thickness and width of the boards cut. Generally the old local units of various countries corresponding to the English foot and inch have been retained in the lumber industry. In addition, the United States and Great Britain have influenced the sale of cut lumber in the markets of the world to a considerable extent. The inch and foot as a meas-

¹ National City Bank, Buenos Aires Branch, Aug. 22, 1916. Letter to New York branch.

² Banco Espanol de Chile, Valdivia, Chile, Sept. 15, 1916. Letter to National City Bank, New York.

³ Henry, F. A., Letter in Bureau of Foreign and Domestic Commerce Report, March 29, 1918, p. 1214.

⁴ United States Consulate, Montevideo, Uruguay, June 29, 1918. Letter to American Institute of Weights and Measures.

⁵ Acting British Consul, Para, *The Decimal Educator*, Dec., 1919. (Letter.)

ure for lumber, therefore, prevail almost universally the world over.

While American lumber has been developed to standard specifications,¹ this is not true of foreign timber. Baltic pine or Austrian spruce, which are cut by each local sawmill according to its own grading rules, often differ from those of other mills even in the same locality.² The diversity of foot measures used in the lumber industry is well illustrated by the following statement as to the manner in which lumber was cut for export by a company in Northern Sweden:³

	(Equivalent)
69% to the English foot.	
7% to the Danish foot.	(0.9711 English foot)
8% to the "Metric" foot (1/3 meter)	(1.0936 English foot)
7% to the Spanish foot	(1.0783 English foot)
4% to the Dutch foot	(1.0768 English foot)
4% to the German foot	(1.0639 English foot)
1% to decimeters	(3-15/16 inches)

In some countries of metric Europe, as in Finland for example, the use of the older units in the lumber industry is specifically exempted from the operation of the metric law.⁴ In Spain lumber is generally sold in feet and inches.⁵ Italy furnishes an excellent example of the different measures in use in the lumber industry. Practically all Baltic pine sent to Italy is cut according to English inches and feet, although some is cut according to meters or French feet.⁶ Establishments in the vicinity of Venice, Trieste and Udine cut lumber according to the Ventian and Trieste measure.⁷ There are also old local measures and standards in Naples, Rome, Milan and elsewhere which are quite confusing.⁸ In the rest of the country the metric system is in common use and is also the standard to which the Austrian, Rumanian and Russian lumber is cut.

In Latin America a similar situation obtains. In isolated instances metric measures are used, but otherwise the English or Spanish foot and inch are generally employed in cutting lumber.⁹

¹ There is, however, considerable diversity in the form of measurement, though the inch is the universal basis. See Hearings before House Committee on Coinage, Weights and Measures, Feb. 6, 1902, pp. 135-137, 141-144.

² United States. Bureau of Foreign and Domestic Commerce, Special Agent Series 182, p. 53.

³ Oxholm, A. X., United States Trade Commissioner, Finland, United States Bureau of Foreign and Domestic Commerce, *Commerce Report*, Feb. 11, 1920. (Lumber Leaflet No. 21, American Institute of Weights and Measures.)

⁴ Magruder, A. R., Chargé d'Affaires *ad interim*, Helsingfors, Finland, July 20, 1920. (Unpublished United States Consular Reports.)

⁵ Bowron, J., United States Consul, Carthagena, Spain. Letter to Henry R. Towne.

⁶ United States. Bureau of Foreign and Domestic Commerce, Special Agent Series 182, p. 46.

⁷ Venetian inch = 1.41 and the Trieste inch = 1.02 English inches.

⁸ United States. Bureau of Foreign and Domestic Commerce, Special Agent Series 182, pp. 52, 53.

⁹ Havana, V. L., Editor, *Ingenieria Internacional*, Aug. 23, 1920.

This is true of Mexico,¹ Colombia,² Venezuela,³ Uruguay,⁴ Chile,⁵ Brazil,⁶ Peru,⁷ Argentina,⁸ and other Latin-American countries.

As to the attitude of the American lumber industry toward a change to the metric system in the United States, the National Lumber Manufacturers' Association made the following statement in reply to the Board's inquiry:

The National Lumber Manufacturers' Association as an association is not committed for or against metric standardization. Most lumber manufacturers, however, are opposed to the adoption of the decimal metric standard of weights and measures because its enforcement in the industry would cause great confusion and entail incalculable expense, in that it would mean the junking of much valuable machinery and innumerable readjustments.

Paper and Printing

Weights and measures are used in the paper and printing industry in the purchase of raw materials, such as wood, rags, etc., in the manufacture of the paper, in cutting paper to convenient dimensions, and in indicating type sizes. In the United States the actual manufacture of paper is carried on in the English system. In the cutting of paper an attempt is being made to adopt a standard sheet 25 by 40 inches or 1,000 square inches. As for type sizes, international practice has now been standardized on a system of points of 1/72 inch. This standard was adopted by the printers of the United States in 1883, and it is found that the same system is used in France and in other metric countries.⁹ Where paper is bought from European dealers it is usually sold in grams or kilograms per square meter.¹⁰ The metric units thus used, however, are merely for convenience in estimating the value of the paper by weight in a metric country and have nothing to do with printing in this country, nor with the cutting of paper into convenient sizes.

Replies to the Board's questionnaire indicated that the paper and printing industries in the United States are decidedly opposed to a change to the metric system. The National Paper

¹ Andres Gomez y Orejan, Lumber and Building Materials, Vera Cruz, Mex., Feb. 23, 1918. Letter to American Institute of Weights and Measures.

² Guyant, O. E., United States Consul, Barranquilla, Colombia, Mar. 13, 1918. Letter to American Institute of Weights and Measures.

³ Banco Commercial de Barranquilla, Venezuela. Letter to National City Bank, New York.

⁴ Bonino & Schroeder, Montevideo, Uruguay, April 26, 1918. Letter to W. R. Grace & Co., New York.

⁵ Voetter, T. W., United States Consul, Antofagasta, Chile, Jan. 31, 1917. Letter to *American Machinist*.

⁶ Gottschalk, A. L., United States Consul, Rio de Janeiro, Brazil, Jan. 6, 1917. Letter to *American Machinist*.

⁷ The Salaverry Agencies Co., Salaverry, Peru, Mar. 23, 1918. Letter to American Institute of Weights and Measures.

⁸ Department of Agriculture, Director General of Commerce and Industry.

⁹ Hallock and Wade, *op. cit.*, p. 173.

¹⁰ United States. Bureau of Foreign and Domestic Commerce, Special Agent Series 163, p. 21.

Trade Association, an organization merchandising paper throughout the country, reported its opposition and the American Paper and Pulp Association made the following statement through its secretary:

The general reaction of the paper industry, as I have secured it by contact with paper manufacturers and through meetings of the Executive Committee of the Association, is against an abrupt change from the present system of weights and measures to the metric system.

The metric system is being used in the paper industry by a few chemists and technical men in laboratory work. So far as we are able to ascertain there has been no adoption of the metric system in actual process of paper manufacture. Some move has been made toward the decimal system in measuring paper and toward the use of metric weights in the purchase and sale of wood.

As the result of war activities considerable effort has been made in the paper industry to achieve certain standardization of product. . . . Standard formulæ are now being used in the manufacture of paper in the way of determining amount of chemicals to be used, amount of different kinds of pulp, etc.

It would be difficult to change from the English to the metric system in the paper industry—difficult because the rather complex machinery used in the manufacture of paper is all based on older systems of measurement. The change will meet with the opposition of the paper merchant or jobber because it would mean the re-printing of all sample books and the teaching of the system not only to salesmen but to the public. Its adoption would necessitate expensive changes in the processing of paper.

As a whole the paper industry is opposed to a compulsory change to the metric system as a sole standard of weights and measures. While the paper manufacturers of the country have not been approached in this matter with a questionnaire, yet the reaction of a very considerable number with verbal inquiry has brought almost universal opposition to the idea.

The Secretary of the United Typothetæ of America had the following to say:

The United Typothetæ of America has never endorsed the metric system for adoption in the industry, and on every occasion when the matter has been presented to the Executive Council it has been dismissed with a small amount of discussion which usually indicated that the governing body was averse to the adoption of the system in the industry at this time. . . .

At the last convention of the Association held in St. Louis in September, 1920, a committee on the standardization of weights and sizes of paper and printing and folding machinery was authorized and has since been appointed. This committee expects to investigate the whole matter of standardization very carefully in conjunction with and in cooperation with similar committees from associations of industries allied with the printing industry.

Chemical and Allied Industries

Weights and measures are used in the chemical industry in experimental or laboratory work and in packing compounds or

liquids in bottles or other containers for sale. Weights and measures are not incorporated in the product itself.

The experimental work in the chemical industry, as has been indicated under "Chemistry" on page 56, is generally based on the metric system. In packing and labeling chemical products conditions similar to those detailed under the canning and labeling of food products prevail; that is, the practice of the community in which the manufacture occurs is followed. That the machinery used in England and the United States in the manufacture of chemicals has been made almost entirely to English standards is indicated by the testimony of individuals and manufacturers. Recently a questionnaire¹ was sent to twenty-one representative chemical manufacturers in the United States. Nineteen reported that they did not use the metric system at all in their manufacturing processes, one that it was used to some extent, and one that it was used exclusively. The testimony of several other chemical manufacturers favors the metric system. For instance, an official of the Xylonite Company, Limited, of Great Britain, which adopted the metric system in 1905, declares that "the initial outlay was, of course, something . . . but the simplicity of the system has been such that we should not think of going back, and all our people now using it are converts to the metric system." Mr. George P. Adamson, of the Baker & Adams Chemical Manufacturing Company, Easton, Pennsylvania, in commenting on the use of the metric system by that company for the past twenty years, states that the metric system facilitates their work decidedly in that it makes calculations easy and simplifies manipulation in the making up of chemicals and solutions.

Regarding the attitude of the chemical and allied industries to a change in systems in the United States, replies to the Board's questionnaire from two associations carrying on widely differing activities in this field will serve to indicate the general sentiment. The American Gas Association reported its belief that the industry as a whole would very much oppose any compulsory change to the metric system as it would involve great inconvenience and expense. In the manufactured gas business, the Association reported, the metric system is used only in chemical analysis. In coke-oven plants it is also used to some extent in the measurement of gas temperatures. All gas meters read in *cubic feet*, and the expense of removing these meters and changing the dials to read in *cubic meters* would be very great. All gas testing instruments, thermometers, barometers, etc., used in this country are calibrated or made to read in English units. Various rules for service adopted by commissions and municipal authorities are in English units; these units are convenient for the purposes of this industry, and great inconvenience would result

¹ Halsey, F., and Dale, S., "The Metric Fallacy," p. 53.

were it necessary to change them. The secretary of the American Drug Manufacturers' Association offered the following information:

The metric system is used to a limited extent in all branches of the industry, which is composed of crude drug millers, essential oil and biological houses, surgical dressings and pharmaceutical manufacturers, principally to supply foreign trade.

The procedure of weighing and measuring products in metric units might be adopted, but would be practical only if universal. Under existing conditions, the majority of buyers demand the English system.

The consensus of opinion in this Association is that the compulsory adoption of the metric system as the sole standard of weights and measures would aid the sale of products abroad, but that the increased foreign sales would be offset by the great difficulties and expense involved in making the change with respect to domestic products.

In the resolutions recently adopted by the Conjoint Board of Scientific Societies of Great Britain opposing the compulsory introduction of the metric system into that country, the chemical trade was specifically excepted.¹ The Society of the Chemical Industry, however, refused to approve this portion of the report, stating that the adoption of the metric system in the chemical trade would be premature.²

Leather and Its Finished Products

Weights and measures are used in the leather industry in the purchase of hides and leather, in tanning and finishing, and in the cutting and making of shoes, gloves, and other leather articles.

Raw leather is bought by surface measure in the units of the country of origin. In metric countries the older natural units rather than the metric are frequently used. In France and Belgium and in some Latin-American countries hides and skins are sold in metric units; ³ in Germany, also a metric country, the prices are quoted in marks per pound or per piece, sole leather prices being given in marks per kilo, and cowhide, box calf and kid in marks per square foot.⁴ In English-speaking countries and dependencies English units are uniformly used.

In the finished products, such as leather belting, luggage, shoes, gloves, etc., the units of the country of manufacture are usually employed in expressing standard sizes, although here again in certain products the older units have persisted in many countries.

¹ Report on Compulsory Adoption of the Metric System in the United Kingdom, Feb., 1920, p. 69.

² *Idem.*, p. 58.

³ *The Leather World*, pp. 102-3, Feb. 3, 1921; Bonino & Schroeder, Montevideo, Uruguay. Letter to W. R. Grace & Co., New York, April 26, 1918.

⁴ United States, Bureau of Foreign and Domestic Commerce. *Commerce Reports*, Feb. 17, 1921, p. 967.

This is true, for example, of gloves. In a French price-list for cutting gloves, the length of the arms, which governs the price, is given in French inches and *lignes*.¹ The numbering of shoes in metric Europe is largely in centimeters. In Latin America imported shoes are numbered according to the English or the metric system, depending on the country of export, while domestic manufactured shoes are numbered either in the metric system or in the old local system which is a remnant of the days when shoes were manufactured by hand. In England and the United States shoe sizes follow the old barleycorn unit of measure ($1/3$ inch). Shoes are numbered in thirteen sizes in which No. 1 equals 4.125 inches and each size adds one-third of an inch.

In response to the questionnaire of the National Industrial Conference Board relative to the question of a change to the metric system in the shoe industry, the Secretary of the National Boot and Shoe Manufacturers' Association replied as follows:

The shoe manufacturing industry has not made any particular study as to the relative merits of the two systems and it would seem at first not very material to this industry whether the present system is continued or the metric system put into use.

The system now in use is the English, although I understand that some manufacturers making army shoes during the war worked under the metric system without any inconvenience.

Other Industries

The larger manufacturing industries briefly reviewed in the preceding sections indicate how weights and measures are associated with the fields of manufacture. Other specific industries might also be reviewed, but for the purposes of this report a detailed analysis of each particular type is unnecessary. A word might be said, however, regarding vehicles for land transportation and especially automobiles and their accessories, the manufacture of which has taken on large proportions in the United States in recent years.

Automobiles

In the manufacture of automobiles, weights and measures are related to the distance between the wheels, the diameter of the wheels, the tread and diameter of the tires, and the dimensions of various machine and other parts of the automobile. The distance between the automobile wheels is usually the same as the standard railway gauge of 56 inches in use throughout the world, even in metric countries. In metric countries, however, there is a narrow gauge for railroads in addition to the standard gauge.²

Since the United States exports a great number of automobiles to foreign countries, the English units used in American manufac-

¹ 1 *ligne* = $1/12$ French inch, and 1 French inch = 1.08 English inches.

² C. C. Stutz, *India Rubber World*, May 1, 1920.

ture come into use in the various countries to which the automobiles are exported, especially in repairs and replacements. This applies particularly to speedometers, spark plugs, and tires, and the various parts of the motor. In certain portions of metric Europe, American-made automobiles play only an insignificant part. In other parts, as in Portugal and Spain, most of the automobiles are imported from the United States. In Latin America also a large trade in automobiles is carried on with the United States.¹ As a result, especial provision must be made in the repair shops of nearly all metric countries for cutting the English thread or in other ways meeting the needs of repairs and replacements as applied to automobiles of American make. Thus in France, Norway, Spain and Sweden both metric and English units are used in repair work and this is likewise true in Latin America.²

The information received through the Board's questionnaire from various sources indicates that the metric system is little used in the United States in the automobile industry and the manufacture of automobile accessories and parts, in the manufacture of railway cars, in the shipbuilding industry and in the manufacture of implements and vehicles. The attitude of the National Automobile Chamber of Commerce is shown in the following statement by the General Manager:

Following our request for an expression of opinion from members on whether the metric system should be made obligatory at this time, the replies indicate clearly unanimous opposition of the members to any such legislation as has been proposed along these lines in Congress.

At the last meeting of the Directors held on March 3rd, 1920, the following resolution was adopted:

Whereas, Efforts are being made to require by congressional legislation the use of the Metric System of Weights and Measures in this country, and

Whereas, A canvass of motor car manufacturers, members of this organization, has failed to develop that any of them are in favor of such legislation owing particularly to the difficulty at this time of changing dies, factory equipment and mechanism and the great cost of same; also the confusion that would be created among workmen who have not been educated in the metric system, be it,

Resolved, That this Board is opposed to legislation making the use of the metric system of weights and measures obligatory, and recommends that members of the National Automobile Chamber of Commerce lend their support to the American Institute of Weights and Measures, which is actively opposing this movement.

Rubber

Largely because of the increasing use of automobiles, the rubber industry in the United States has grown very rapidly in recent

¹ United States, Bureau of Foreign and Domestic Commerce. *Commerce Reports*, Jan. 24, 1921, p. 435.

² *Ibid.*, Feb. 9, 1921, pp. 797-801.

years. Most of the crude rubber comes from South America where it is sold by the kilogram.¹ Over 87 per cent of the crude rubber of the world in 1919 was consumed by the United States, Canada, and Great Britain.² In the United States practically all kinds of rubber goods are manufactured in standard sizes based on the inch measurement.

In the manufacture of rubber tires in the United States the custom is to build them to standards expressed in inches and then to mark them, where export trade to metric countries is involved, in both the English and the metric system. To a large extent each factory has its own specifications in making its tires.³

In Peru and Venezuela the majority of tires are imported in inch sizes from the United States and this is likewise true of other Latin-American countries.⁴

In response to the Board's questionnaire, replies were received from two of the leading tire and rubber companies of the United States. One of the companies favors the use of the metric system, the change to be gradual only. It does not favor legislation making its use compulsory throughout the United States. The following expresses its attitude toward and experience with the metric system:

Our factory Manager and Vice-President has been in favor of the metric system for some time and we have been using metric units exclusively in about a half dozen of our Production Departments for the last few years. These have been used quite successfully and we find that the clerical work involved is less than with the old type of English units and also that the men learn to handle the weights and measurements in metric units very readily.

We make a distinction between our Production and Engineering Departments. In our Production Departments we handle weights, lengths, thicknesses and capacities and it is possible to change our equipment for these measurements over to the metric system without a great deal of trouble or expense. Our Engineering Department and machine shops, however, are dependent upon outside shops and outside sources of supplies as far as standard parts are concerned and it is, therefore, not advisable to change over to the use of the metric units until engineers and machine shops throughout the country make this change. We expect eventually to change over the balance of our Production Departments to the metric system but this will probably not be done for some little time.

We favor the use of the metric system but do not favor legislation which will make the use of the metric system compulsory throughout the United States.⁵

¹ Reyuser y Taulmnat, Montevideo, Uruguay, July 31, 1916. Letter to National City Bank, New York; National City Bank of New York, Santos, Brazil, Sept. 11, 1916. Letter to New York Branch; D. Meyer & Cia Bahia Blanca, Argentine, July 31, 1916. Letter to National City Bank, New York.

² *India Rubber World*, New York, March, 1920, p. 485. "The London View of the 1919 Crude Rubber Market."

³ Wormeley, P. I., United States. Bureau of Standards. "International Standardization of Automobile Tires."

⁴ United States. Bureau of Foreign and Domestic Commerce. *Commerce Reports*, Feb. 26, 1921, pp. 1077-85.

⁵ The Goodyear Tire & Rubber Company, Feb. 28, 1921. Letter to N. I. C. B.

The other tire and rubber company indicated that the metric system was used only in its laboratory and scientific work and that there was no desire to adopt it for the plant as a whole. At present the product is standardized largely on the English system. The use of the metric system would not, according to the statement of this company, aid in the sale of its products either in domestic or foreign trade. Considerable difficulty and expense would be encountered in a change to the metric system and the process of manufacture would necessarily have to be changed to a large extent. This company expressed itself as strongly opposed to a change.

Miscellaneous Industries

Replies to the Board's questionnaire were received also from five plants making brass goods, two making bronze goods and four making aluminum goods. Ten of the eleven plants reported that the metric system was not used in their establishments, while the eleventh reported that it was very little used except in laboratory work. None indicated a desire for the adoption of the system. One bronze manufacturer stated that the use of the metric system might help in foreign trade but the others reported that it would not help at all. The same plant, and two others, indicated that the change would probably not involve much difficulty and expense and would require little or no change in process. The other eight plants reported that it would involve difficulty and considerable expense and would require some change in processes. On the whole the replies indicated the same strong opposition to the compulsory adoption of the metric system as was expressed by other manufacturing industries and concerns.

RELATION TO QUESTION OF CHANGE IN UNITED STATES

As regards the bearing of a compulsory change to the metric system in the United States, a reverse situation obtains in the manufacturing field from that indicated for the fields covered in the last chapter. This is due to the nature of the products resulting from manufacturing processes. Weights and measures are not intrinsically bound up with the products of agriculture, mining, transportation and trade. Manufacturing, on the other hand, is the field in which things are made to measure, and whatever measures are used are intimately tied up with the resultant product.

A brief review of the relation of weights and measures to various classes of products, both raw and finished, will be helpful to a clear understanding of this distinction, the classification falling logically into four groups:

(a) For bulk products for immediate consumption, such as grain, coal, nitrates, etc., the original measure is of small moment since it is used chiefly as a medium for estimating the value of the product, and for determining quantity.

(b) Weights and measures enter to a greater extent into goods for immediate consumption in which the original measure is incorporated as a part of the product, such as canned goods, textiles, ready-made clothing, etc., and the necessity for some degree of standardization arises. With such commodities the chief consideration is that the consumer be familiar with the unit of measure or weight employed. In ready-made clothing and similar products particular needs of the consumer must also be met.

(c) There is a third class of goods which are not intended for immediate consumption but perpetuate for a considerable period of time the units incorporated in them. Such goods include machinery, building material, etc., which later must be repaired or replaced. In this class it is evident that a still greater desirability for standardized practices exists and that a change in weights and measures would create considerable difficulty.

(d) Finally, there is a class of goods which is inextricably bound up with the measurement itself, such as weighing scales and measures, precision tools, gauges, taps and dies, products containing screw threads, etc. In this class standardization is absolutely essential and a change in the system of weights and measures employed would often necessitate the discarding of the products themselves.

Peculiarities of Manufacturing Field

It is apparent from the preceding classification that all but the first group is intimately related to the manufacturing field. Here is seen the important distinction, in relation to the question of weights and measures, between the measuring of a thing already existing and the making of something to measure. In science, for example, the primary consideration is a unit of measure that will afford absolutely accurate measurements and which can be easily handled from the standpoint of computation. In such a field a change from one means of measuring objects to another is relatively simple. On the other hand, in the making of a commodity to measure, the important considerations are that the product be made of convenient size or of handy weight and that the measure or weight adopted be perpetuated if the business built up about the particular product so made is to continue and be successful.

An examination of the preceding classification brings to light another fact bearing on the relation of the manufacturing field to a change to the metric system. Implements and machines by means of which agriculture, mining and transportation and manufacturing itself are carried on are the products of the manufacturing field. The tools and processes employed in the manufacturing field in the making of a thing to measure would have to undergo a change if the measure itself were changed. Costly patterns, moulds, forms, and tools which cannot be adjusted or

altered and the multifarious drawings and specifications which enter into so many lines of manufacturing industry would be so affected, as would likewise the vast amount of technical literature relating to engineering and its allied industries, all of which would have to be rewritten to bring its tables of figures, constants, etc., into conformity with the metric system. Again, where products are manufactured with standardized and interchangeable parts, a change in weights and measures would mean that such parts could not be replaced under the new system and that the units of the old system must be retained in part at least, to provide for the replacement of machine parts built in the other system.

Comparison of Manufacturing in the United States and Elsewhere

In the manufacturing field, in short, a change in weights and measures would involve a much more difficult problem than in the other fields examined, in which connection the experience of other countries in adopting the metric system, whether it is looked upon favorably or otherwise, forms no parallel by means of which to judge the effect of such a change in the United States. The metric system originated in France before recent manufacturing development, while in Germany and Belgium the system was adopted before those countries became in a large sense manufacturing nations, so that in the adoption of the metric system in these countries no great change of manufacturing units was involved such as would naturally be expected were the system to be adopted in the United States.

The persistence of old customs in manufacturing as well as in agriculture and mining, in countries enforcing the use of the metric system by compulsion, is a further indication of the difficulty of making a change in these basic industries. As has been pointed out, in most metric countries very little success has been experienced in enforcing metric laws in going behind the wholesale commercial transaction into the actual production of the commodity. Old units still obtain today in such industries as were in existence in early times in France and Germany, i. e., the silk industry in France, the wool industry in Germany, and the lumber industry in both countries. A large factor making for the continued use of older units of weight and measure in manufacturing industries, has been the commercial dependence of smaller countries upon the larger industrial nations, both for their supply of raw materials and for their productive machinery. In some instances workers familiar with a given industry were imported from the country of origin in order more successfully to carry on the industry in another country. The cotton industry was instanced as an example of how the English system was carried from Great Britain to Germany, where it prevails in the cotton industry to-

day. In other industries in various countries where machinery and materials are to a large extent imported from the United States or Great Britain, English measurements are used in spite of metric laws. A change to the metric system in this country, therefore, would not only affect adversely the field of manufacture here, but would likewise affect American products in foreign countries.

Summary of Relation of Weights and Measures to Manufacturing Fields and of Opposition to Change in Systems

The survey in this chapter of various specific manufacturing industries serves to indicate how intimately weights and measures are tied up with the products of manufacture and how widely English units are used in various industries the world over. In textiles the English yarn counts (yard-pound) are used in practically every country, especially in the cotton industry. In metal products, English machine standards based on the inch predominate even in metric countries. In food products weights and measures are used mainly in packing and labeling and follow the customs in the various countries carrying on canning industries, the tendency in the United States being to label cans in both English and metric measures. In lumber, the inch and foot (mainly English but including other natural inch systems) prevail almost universally in the cutting of boards. In paper and printing, type sizes have been standardized in the United States, France and elsewhere on the basis of the inch. In the chemical industry the metric system is used in experimental work, but hardly at all in chemical production, the machinery employed being made largely to English measurements even in metric countries.

It has been brought out also, through an examination of replies to the Board's questionnaire, that there is a decided opposition to a change to the metric system among manufacturers in the United States. The textile industries expressed themselves as completely satisfied with the present system of weights and measures and as opposed to efforts to change it. Over 90% of the metal products industry registered decided opposition to a change. The food products industry showed similar opposition. The lumber industry was likewise opposed and emphasized the "great confusion and incalculable expense" that would result. The paper and printing, automobile, railway car, shipbuilding, and implement and vehicle industries also went on record as decidedly adverse to any change.

The manufacturing field, employing as it does over 10,500,000 workers, and producing commodities valued at something like \$25,000,000,000 annually, is unquestionably one of the most important fields of industry in the United States. The indications are

that a compulsory change to the metric system would profoundly affect many manufacturing lines, especially during the period of transition, which the experience of other countries suggests would be very long. The interests and desires of such an important field and the effect of a change in weights and measures upon it should naturally be carefully weighed in considering the advisability of a compulsory change.

CHAPTER IX

FOREIGN TRADE

In one sense foreign trade is a subdivision of the general field of trade discussed in Chapter VII. As related to weights and measures, however, foreign trade stands in a class by itself and for that reason is analyzed separately.

As shown in Table I, Chapter V, the value of the products exported from the United States in 1914 was 2 billions of dollars out of $37\frac{1}{2}$ billions of total production, or $5\frac{1}{2}\%$ of the whole. In Chapter VII, page 74, it was pointed out that in 1910 there were considerably less than 50,000 importers and exporters in the United States out of a total of 38 million productive workers ten years of age and over, i. e., not more than one-tenth of one per cent of the whole. Many manufacturing industries, however, carry on a considerable foreign trade through individual concerns, so that the number of people engaged in foreign trade in the United States is somewhat larger than indicated in the census figures. It should be noted, also, that the export trade of the United States has increased from 2 billions in 1914 to over $7\frac{1}{2}$ billions of dollars in 1919. Everything considered, foreign trade activities constitute but a small fraction of the total productive activities of the nation, although such trade has an important bearing on all industry.

By its very nature foreign trade transcends national boundaries, so that it is necessary to examine the world-wide aspects of its relation to weights and measures as well as its particular relation to a compulsory change to the metric system in the United States.

ANALYSIS OF WORLD TRADE

To give a clear picture of the application of the English and metric systems to world trade, it will be indicated first, what proportion of the trade of the world is carried on respectively by English, metric and other countries; secondly, how the export trade of English countries is apportioned among metric and other countries; and thirdly, what the relative importance of the various products entering into such trade is.

World Trade in Exports and Imports

In presenting the trade of English, metric and other countries, the same classification is adhered to as was indicated in Part I, namely,

- (a) countries in which the metric system is in predominant use,
- (b) countries in which the English system is in predominant use, and
- (c) other countries.

Below is given a table of world trade for 1919, showing the total imports and exports and the proportion of the whole carried on by these three groups of countries.

TABLE III
DISTRIBUTION OF WORLD TRADE ACCORDING TO USE OF METRIC, ENGLISH
AND OTHER SYSTEMS¹

	Total Imports 1919 (Dollars)	Per Cent	Total Exports 1919 (Dollars)	Per Cent
Metric countries....	26,450,483,000 ²	58.9	11,334,271,000 ²	37.5
English countries....	14,312,158,000	31.8	14,553,705,000	48.2
Other countries.....	4,180,802,000	9.3	4,336,075,000	14.3
Totals	44,943,443,000	100.0	30,224,051,000	100.0

¹ The statistics for this table were for the most part taken from the "Statistical Abstract of the United States," Department of Commerce, 1920, Table No. 454, pp. 838-9, and "Statesman's Yearbook," 1920. The imports and exports of the individual countries represent statistics for the latest available date, in most cases for 1919, converting at par the foreign monies into dollars. Some discrepancy is therefore to be expected and, in the present state of international uncertainty, the figures should be regarded as indicative merely. They are accurate enough, however, for the purpose of the rough classification herein attempted. For detailed figures on individual countries see Table VII of the Appendix, which serves as a basis for this table.

² Includes trade of Germany, converted into dollars at par, which because of the depreciated value of the mark swells the metric total somewhat abnormally; cf. Table VII, Appendix.

With respect to exports, Table III indicates that English countries, principally the United States and Great Britain, transact nearly half the export trade of the world and that metric countries transact slightly more than one-third. With respect to imports, the table indicates that over one-half of the total imports of the world came into metric countries, and less than one-third into English countries. In short, English countries export a greater proportion of the total than they import, while metric countries import a considerably larger percentage of the whole than they export.

In interpreting the meaning of these and other trade figures with respect to weights and measures, several factors which have a bearing here should be considered. It is necessary to ascertain whether the goods exported from one country and imported into another are mainly in the form of raw materials or manufactured products in which weights and measures are incorporated and perpetuated, and also how far the receiving country allows its people to use the weights and measures thus brought in through trade with other countries. The first consideration will be taken up more in detail in a following section.

With respect to the second, it is interesting to note that a large number of metric countries allow the use of weights and measures brought in through trade. This is especially true of Latin America, but also to a large extent of metric Europe, where other than metric units are usually permitted when the interests of foreign trade require it. In Latin America most importers are familiar with English weights and measures, and goods received from English countries are not generally changed to conform to metric units. The only requirement usually made in the customs laws regulating consular invoices and other shipping and custom-house documents is that the entries there be converted and made in the metric system. In some lines of trade for more than a generation Latin America has received goods measured only in the English scale.¹ This is particularly true of Nicaragua,² Uruguay,³ Brazil⁴ and other Latin-American countries doing considerable importing from the United States.

In short, the general export and import figures presented indicate that the English system of weights and measures is being projected into metric and other countries through the export trade of Great Britain and the United States to a very considerable extent and that the reciprocal influence of the metric system in English and other countries is much smaller. The export trade of the world according to the latest available figures is graphically presented in the chart on the opposite page.

These general figures, however, useful as they may be for presenting in broad outline the world trade picture with respect to the use of the English, metric and other systems, do not show the actual trade relations *between* the three groups of countries listed. They do not indicate, for instance, what portion of the export trade of English countries goes to metric countries, or what proportion of the export trade of metric countries goes to English countries, or whether "other countries," including the vast markets of the

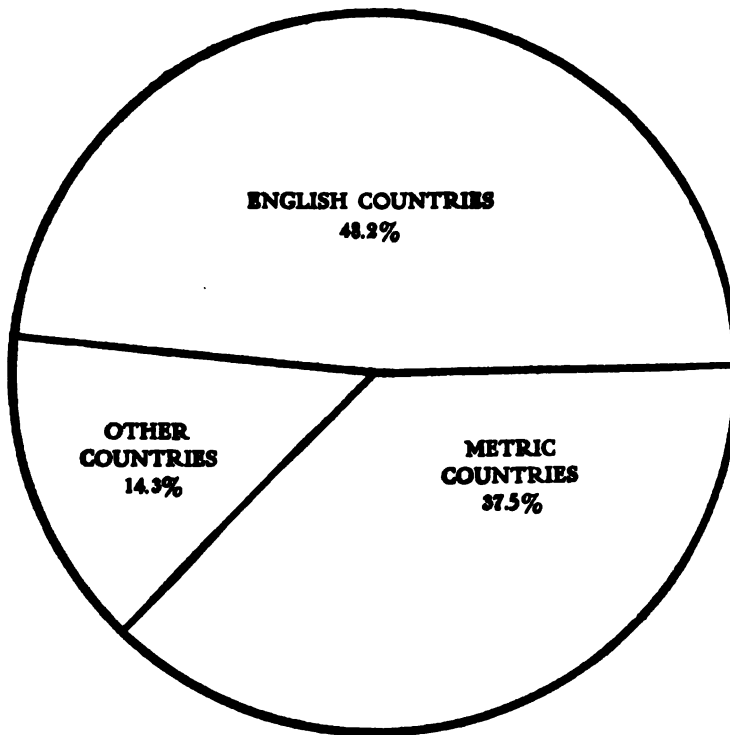
¹ Atlas America Latina, "Weights and Measures," pp. 15, 16, 17.

² McConnico, A. J., United States Consul, Corinto, Nicaragua, Feb. 20, 1918. Letter to American Institute of Weights and Measures.

³ Bonino & Schroeder, Montevideo, Uruguay, April 26, 1918. Letter to W. R. Grace & Co., New York.

⁴ Salgado, Rogers & Company, Ceara, Brazil, Sept. 21, 1916. Letter to National City Bank, New York.

DIAGRAM III
DISTRIBUTION OF WORLD EXPORT TRADE
ACCORDING TO COUNTRIES USING VARIOUS
SYSTEMS OF WEIGHTS AND MEASURES
(1919—OR LATEST AVAILABLE DATE)
(National Industrial Conference Board)



As indicated in Diagram II, p. 19.

"English Countries" represents 12 Countries in which the English system predominates.

"Metric Countries" represents 37 Countries in which the Metric system predominates.

"Other Countries" represents 28 Countries in which neither the Metric or English system predominates.

Orient, import more from the English than from the metric group. Some light on these questions will be obtained from the following sections of this chapter.

Trade Between English, Metric and Other Countries

In Table VI of the Appendix is given the total imports for 1913 and 1918¹ of individual metric and other countries and the percentage of these imports received from the United States and from Great Britain. Included in this table are countries of Latin America that cannot be fully classified as metric countries, but which have been listed for the purpose of giving a complete picture of the trade relations of the United States and Great Britain with Latin America, since Latin America is usually regarded as a unit in discussions of trade relations, irrespective of the fact that this region includes English and "other" countries as well as those preponderantly metric. Setting off Latin America as a distinct group forces a rearrangement of the three-fold classification, with respect to weights and measures, thus far adhered to in this report. This rearrangement forms the basis for Table IV given on page 111, as well as for the present discussion.

Trade of the United States and Great Britain with Latin America

Table VI of the Appendix indicates that the trade of the United States with Latin-American countries increased in large proportion from the time of the outbreak of the European war, with the result that at the end of the war the United States held a predominant position in such trade, having secured a considerable portion of the former trade of Germany, France and Italy. This holds true for South American as well as Central American countries.

The percentage of imports from the United States into the ten South American countries more than doubled since 1913 in six countries and in the other four countries increased nearly as much. In all but Uruguay and Paraguay the percentages were considerable in 1918. With respect to Uruguay and Paraguay it should be noted that their chief imports came from other South American countries, such as Argentina, which in turn are large importers from the United States. There was but a slight change in the South American imports from Great Britain during the periods studied. In general, from 20 to 30% of the total came from Great Britain.

Imports into Mexico, Central America and the West Indies from the United States in 1913, in every country except one were more than 50% of the total imports into these countries, reaching as high as 87% in Honduras. The trade of the United States

¹ Or for latest available date.

with these countries increased considerably, with the result that in 1918 American products ranged from 56.2% of the total imports of Salvador to as high as 94.4% in San Domingo and Haiti. The imports from Great Britain on the other hand suffered a decrease in all these countries excepting Guatemala during the same period.

In 1913 the combined imports from the United States and Great Britain into South American countries averaged 44% of the total and by 1918 they averaged 58.1%. In Mexico, Central America and the West Indies, such combined imports increased from an average of 65.5% in 1913 to 83.4% in 1918. These figures indicate that in 1918 the United States and Great Britain contributed more than half of the imports into South American countries, and held by far the predominating position in the import trade of Mexico, Central America and the West Indies. A significant portion of the remaining imports represents the reciprocal trade of Latin-American countries among themselves. It should be borne in mind, however, that although Latin America secures most of its imports from the United States and Great Britain, from the point of view of the United States as indicated on page 111 her trade with metric Latin America is much less than her trade with metric Europe. It is even less than her trade with the group of "other countries."

Trade of the United States and Great Britain with Metric Europe

The United States and Great Britain have apparently even in normal times been carrying on a considerable trade with metric Europe, in spite of the fact that the trade relations of continental Europe are, in the main, reciprocal within the group,—Germany, Austria-Hungary, Italy, France, Belgium and the Netherlands holding the leading positions prior to the war. Thus, although the *proportion* of such trade contributed by the United States and Great Britain has been small, the actual *amount* has been considerable.

Prior to the war, from the point of view of European metric countries, the United States contributed in 1913 less than 12% of their total imports. The percentage of Great Britain's contribution was even less—hardly as much as 10% of the whole.

The war affected the trade of Europe tremendously, and such trade is still in a very unsettled condition. The statistics presented in Table VI of the Appendix indicate that the percentage of imports into metric Europe from the United States and Great Britain have increased considerably since 1913, imports from the United States more than doubling those of Great Britain, but these figures must be viewed in the light of the abnormal trade

conditions still prevailing throughout Europe and of the resultant disturbance in exchange values.

Whatever the percentage of increase, however, from the point of view of the United States the late figures, as summarized in Table IV on page 111, show that trade with European metric countries forms a very important part of American export trade, considerably more in fact than the trade of the United States with Latin America and "other countries" combined.

Trade Between English and Other Countries

With respect to the comparative status of English countries and European metric countries in the trade of "other countries," adequate figures showing the distribution as regards source of imports into "other countries" are lacking. In consequence the whole question of the relative status of the English versus the metric system in the import trade of such countries is controversial. Certain data, however, such as that given in Table VIII of the Appendix regarding the comparative parts played by English and metric countries in the import trade of Japan and China, indicate that English countries occupy a position of far greater importance in this import trade than do European metric countries. Before the war metric countries contributed less than 15% to the import trade of Japan and less than 10% to that of China, and in 1918 such trade had disappeared almost entirely. On the other hand, before the war Great Britain and the United States alone contributed 36.2% to Japan's imports and 24.3% to China's, while trade with British dominions and through Hong Kong added greatly to these figures. Furthermore, by 1918 the trade of the United States with both China and Japan had more than doubled. The figures given in Table IV on page 111 indicate also that from the point of view of the United States, her trade with "other countries" holds an important position in her total export trade, even exceeding that with Latin America.

Summary

The general trade relations of the United States and Great Britain, representing roughly the English group of countries, with Latin America, with European metric countries, and with the group of "other countries" may be summed up as follows: While exports to Latin-American countries from English countries form a relatively small percentage of the total exports of English countries, they constitute the larger part of the imports of the Latin-American group, the position of the United States in the import trade of the Latin-American group having increased considerably since 1913. At the close of the war the United States and Great Britain held a predominant position in the import trade of Latin America, and the United States shows a tendency to forge ahead

of Great Britain in this trade. On the other hand, while the trade of English countries with European metric countries normally forms but a small part of the import trade of this metric group, it constitutes a very large proportion of the export trade of English countries, i. e., the United States and Great Britain actually carry on considerably more trade with metric Europe than they do with Latin America and "other countries." This whole situation, however, is in a state of flux due to unsettled conditions existing in Europe.

Likewise due to unsettled conditions and to lack of available statistics, it is not possible to present an adequate picture of the present relative importance of the trade of the English group and of the European metric group with the general group of "other countries," including the Orient. From such material as is at hand, it seems probable, however, that normally English countries play a more important part in the imports of "other countries" than European metric countries do.

In short, a survey of the trade relations of the English, European metric, Latin-American and other countries indicates that the English system of weights and measures enters more largely into the total foreign trade of these groups than does the metric system. This general observation is strengthened by a consideration of the character of the products entering into this trade.

Relative Importance of Various Products in Trade of English and Metric Countries

The last column of the Appendix Table VI examined in preceding sections lists in order of importance the various products imported from the United States and Great Britain into Latin America and metric Europe during the periods studied. Metric Europe is both agricultural and manufacturing in nature and its imports consist very largely of raw materials received from Latin America. As shown in Table VI of the Appendix, however, the United States and Great Britain contribute to the imports of metric Europe a considerable amount of manufactured products, into which English units enter very largely.

Latin America, on the other hand, is in the main an agricultural and mining region and has not advanced far in manufacturing. Its exports therefore consist chiefly of raw products and its imports of manufactured products. Statistics indicate that while the exports of Latin America in raw materials go to Europe, its imports in manufactured products since 1913 have come largely from the United States and Great Britain. As indicated in the table, textiles hold the leading place in the

import trade of Latin America. Food products, consisting largely of flour, bread stuffs, dried fish, packed meats, and other canned goods and manufactured food products, hold second place in value of imports into most Latin-American countries. Metal products and machinery hold the next place. Other important products imported into Latin America from the United States and Great Britain are chemicals and drugs, lumber, leather, and paper products, and such minerals as petroleum, oil and coal. Comparing this list of products with the discussion of various manufacturing fields taken up in Chapter VIII, it is apparent that the products imported from the United States and Great Britain into Latin America are chiefly those in which the English system of weights and measures is most definitely incorporated.

Summing up the whole discussion of the world-wide aspects of the English and metric systems in foreign trade, it appears that general export and import figures, trade relations between English, metric and other countries, and the nature of the products exported from English countries, all confirm the observation already made that the English system of weights and measures is being projected into metric and other countries to a very considerable extent through the export trade of the United States and Great Britain and that the reciprocal influence of the metric system is much smaller.

RELATION TO QUESTION OF CHANGE IN THE UNITED STATES

Reviewing the field of foreign trade as other fields have been reviewed, from the standpoint of the nature, fabrication, and sale of the products involved and the bearing of a compulsory change to the metric system in the United States, it is apparent that uniformity in the weights and measures used in foreign trade is desirable. This, however, does not touch the question of whether the metric or the English system is best adapted or most likely to become the universal system for foreign trade, nor does it touch the specific question of whether the English system should be discarded for the metric in the United States. Preceding sections have indicated the relative positions held by English countries and metric countries in the world's export trade. The nature of the products exported by the United States and Great Britain to metric countries was also indicated. The facts presented above, together with the following bearing specifically on the exports of the United States, must be carefully weighed in considering the advantages to be gained or lost in the foreign trade of the United States by a compulsory change to the metric system.

Exports of the United States

The exports of English countries in 1919, as stated on page 103, totalled over 14½ billions in value. Of this total the United

States exported over 7½ billions or more than one-half the whole. These exports were apportioned among English, metric and other countries according to the most important trade groups as shown in the following table and the chart on page 113.

TABLE IV

DISTRIBUTION OF EXPORTS OF THE UNITED STATES, ACCORDING TO GROUPS OF COUNTRIES USING VARIOUS SYSTEMS OF WEIGHTS AND MEASURES, 1919¹

English ²	3,274,772,000	41.9
European Metric	2,904,905,000	37.1
Latin American Metric	493,531,000	6.3
Latin American English and other...	444,766,000	5.7
All other countries	701,641,000	9.0
Total	7,819,615,000	100.0

¹ Based on export statistics taken from "Statistical Abstract of the United States," 1920. Table No. 288, pp. 398-425. Cf. footnote (b), Table VII of Appendix.

² Does not include three "English Countries" comprised in the Latin-American group (Porto Rico, British Guiana, San Domingo).

³ Includes three metric countries (Philippines, Congo, Tunis).

Combining the figures presented in the foregoing table so as to separate metric countries from all others including the English, it will be seen that considerably less than half (about 44½%) of the export trade of the United States is with metric countries, while considerably more than half (about 55½%) is with the rest of the world. Considered as they stand, the figures in this table indicate also that the export trade of the United States with Latin-American metric countries does not loom up in the total export trade of the nation so prominently as is frequently assumed, constituting as it does only slightly more than 6% of the total American export trade, that is, even less than the export trade of the United States with the group headed "all other countries."

It was indicated on pages 109-110 that the products imported into metric countries are in the main manufactured articles in which English weights and measures have been incorporated. In textiles English standards are in force even in metric countries, so that in a compulsory change to the metric system in the United States this industry would doubtless have to be exempted from the use of the system. In food products and chemicals, American exporters are adopting the practice of labeling in metric as well as English units goods packed in cans or other standard containers, which practice is apparently quite satisfactory to importers in metric countries. The practice in the lumber industry is on the "inch" basis the world over, so that this industry would likewise have to be exempted. With respect to metal products and ma-

chinery it would apparently create serious confusion if it were necessary to destroy the existing mechanical standards based on the English system in the United States. As far as trade with metric countries is concerned, a compulsory change to the metric system in the United States would have to take into consideration the bearing of these facts.

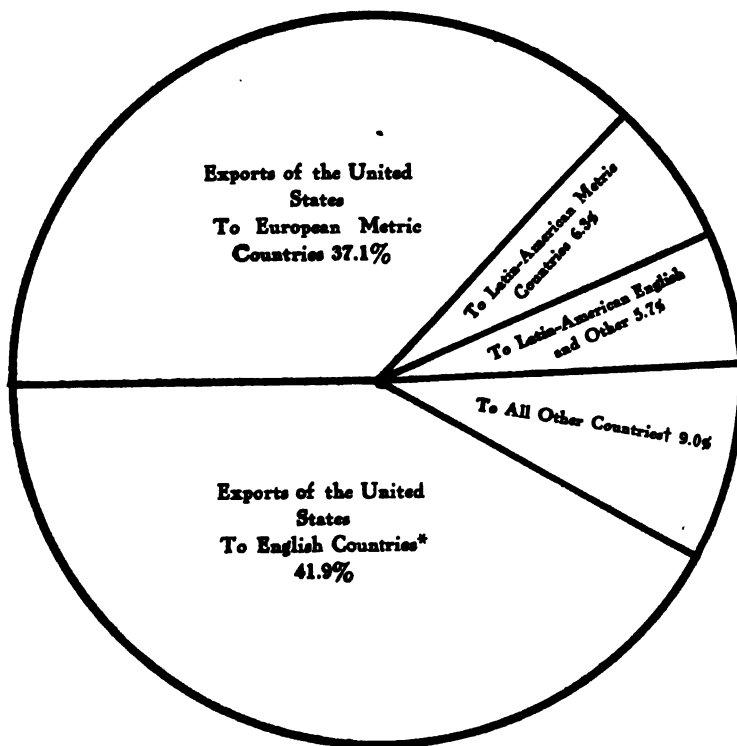
On the other hand, as has been indicated, considerably more than half of the export trade of the United States goes to countries that are not predominantly metric, and the effect of a compulsory change to the metric system in the United States upon such trade must likewise be taken into consideration. It is reasonable to suppose that if the United States stands to gain any trade with metric countries as a result of a compulsory change, it likewise stands to lose trade with English and other countries where its trade is already established on the basis of the English system.

In reply to the Board's questionnaire sent out to the manufacturers of the country inquiring into the extent of use of the metric system and its desirability as an aid to foreign trade, a variety of answers was received. Some firms indicated that the use of the metric system would aid in the sale of products to Latin America and the metric countries of Europe, while others stated that it would aid in the sale of products to certain countries in Europe but that there was no demand for their products in metric units from Latin America. Other establishments reported that the advantage from the use of the metric system in the sale of products to Latin America and metric European countries would not offset the loss in trade to non-metric countries. Still others reported that it might aid in their foreign sales but that this would not offset the disadvantage in their domestic sales. A large number reported that they had very little or no foreign trade.

In brief, the interests of foreign trade are naturally along the line of establishing a uniform system of weights and measures the world over. So long as substantial uniformity is secured, however, there is no reason why this field should prefer any one system over another except as one or the other system is found to be already in predominant or increasing use. The facts indicate that the trade of the world is not carried on more in the metric system than it is in the English and that, as a matter of fact, the English system predominates. Furthermore, in considering a compulsory change to the metric system in the United States, the loss of the nation's vast trade with English and other countries must be weighed over against any gain in trade that might be secured with metric countries.

DIAGRAM IV.
DISTRIBUTION OF EXPORTS OF UNITED STATES
ACCORDING TO GROUPS OF COUNTRIES USING VARIOUS SYSTEMS
OF WEIGHTS AND MEASURES—1919

(National Industrial Conference Board)



*Does not include three "English Countries" comprised in the Latin-American group (Porto Rico, British Guiana, San Domingo).

†Includes three "Metric Countries" (Philippines, Congo, Tunis).

CHAPTER X

SUMMARY OF SITUATION REGARDING THE USE OF METRIC AND ENGLISH SYSTEMS IN SPECIAL FIELDS

The general facts outlined in Part I regarding metric legislation in various countries do not completely reflect the situation respecting the actual use of metric, English or local systems in those countries. The actual use of systems is affected not only by the laws regarding them and the enforcement of these laws, but as has been described in the preceding pages of Part II, by industrial, business and trade factors and by the popular customs of each country. Some fields of activity are more concerned or differently concerned with weights and measures than others and the desirability of, the demand for, and the difficulty of making a change, as well as the effectiveness of legislation, varies with the character of the field, its activities and products.

It is found that in those countries in which the metric system has been made optional only, its voluntary use has not extended beyond such fields as science and those branches of manufacturing making use of minute measurements. In those countries in which the metric system has been made compulsory for government uses, it has spread little beyond official departments. Even where the law makes the metric system compulsory for all uses, and the law is in any great measure enforced, very few metric countries have been able to secure its adoption beyond legal transactions and in wholesale domestic trade; and in a number of countries specific exemptions have been made allowing the use of old units in certain fields, such as in the timber trade, in land measurements, in engineering, in measuring drafts of ships, etc. In the field of domestic trade, it has sometimes happened that a compromise has been made between the old terminology and the metric units, thus satisfying the legal requirements while retaining old national or local names. Such basic industries as agriculture, mining and manufacturing have been little affected by the operation of compulsory metric laws.

The reasons for the continuance of old customs in spite of compulsory laws are, in general: (1) In a number of special

fields, the effort toward national unification on the basis of an entirely new system has appeared to offer little advantage, if any, over the old units; (2) the difficulty and cost of introducing a new system in the field has appeared greater than any benefit that could be derived from complete unification on the basis of that system; (3) factors of international trade, built upon older units, have encouraged the persistence of these units.

In general, *in pure or laboratory science*, where the products are discoveries, inventions, scientific books, etc., where methods are changing, where there is little relation to the habits of the public in general, and where interests are unaffected by a change, the metric system is generally favored and used. Fields requiring minuteness of weighing and of measurement, such as medicine and pharmacy, and the manufacture of delicate instruments, likewise favor the metric system, although in English countries the English system is also largely used in these fields.

The engineering professions are as closely related to modern industry as they are to science, and the use of metric units in these professions is not at all general as in the field of pure science. In electrical engineering, the metric system is in use combined with other non-metric units, there being as yet very little uniformity or strict adherence to one system. In mechanical engineering, the use of the English system is predominant. In civil engineering and land measurements, where permanent records and legal considerations are involved, the use of old units is general and in many countries explicit exception to compulsory laws is made, permitting their use. The interests affected by both scientific and engineering fields of activity in the United States are comparatively small, comprising in 1910 about 500,000 productive workers, including those engaged in the manufacture of fine instruments, or about one per cent of the total productive population of the United States.

In the field of *agriculture*, old natural units of weight and measure have persisted in practically every country, because the specialized needs of various products of agriculture have brought about certain practices closely adapted to natural needs, very generally associated with natural systems of weights and measures, and having little to do with a scientific system such as the metric. Practically no demand has developed on the part of agriculturalists in any country for the adoption of the metric system.

In the field of *mining*, the weights and measures generally used are the national units of the country, unless the mining operations are carried on by a foreign company, in which case the engineering practice of the operating company usually prevails. In countries

where the mining industry has been long established, the old units used by the native miners have persisted.

In the field of *land transportation*, the system used, being closely bound up with railroad rules, regulations and practices, which in many countries are established by the government, tends to follow the system required by legislation or that in general use in other fields. In *water transportation*, the English nautical mile is the world's standard, accepted by even metric countries, and displacement is usually expressed in English tons. The unit in which ocean freight is measured and rates and tariffs calculated, depends generally upon the nationality of the vessel, but the English ton is frequently used for such purposes also.

In *wholesale trade*, where commodities are bought and sold in large trade centers and the sale is often subject to contract or bill of sale, there is direct opportunity for the enforcement of national regulations. In consequence, the system in use in this field tends to follow closely the legislative requirements in various countries. In *retail trade*, however, old units of weight and measure have persisted in spite of the metric laws, there being considerable diversity in this respect in all metric countries.

In agriculture, mining, transportation and trade, the interests affected by a change in this country would be considerable. The workers engaged in these fields in 1910 were about 20,000,000, or 52 per cent of the total productive working population. Weights and measures are used in agriculture and mining chiefly to facilitate the handling and valuing of the products, for they are not incorporated in the products themselves; and the material effect of a change in systems would be the almost total discarding of weighing and measuring implements used in agriculture and mining and also in transportation and trade, and new implements would have to be supplied by manufacturing industries. The habits of the entire buying and traveling public, as well as of those directly engaged in selling and transporting goods, would also be affected by a change.

In the field of *textile manufacturing*, the English system of measurement peculiar to this industry is used in practically every country, especially in the making of cotton products. In *metal manufacturing*, the English machine standards, based on the inch, are generally used even in metric countries. In *food products*, weights and measures are used mainly in packing and labeling and follow the customs in the various countries carrying on canning industries, the tendency in the United States being to label cans in both English and metric measures. In *lumber*, the inch and foot (mainly English, but including other natural inch systems) prevail almost universally in the cutting of boards. In *paper and printing*, type sizes have been standardized in the United States, France and

elsewhere on the basis of the inch. In the *chemical industry*, the metric system is used in experimental work, but little in chemical production, especially in the United States. In other industries, also, such as automobile manufacturing, English units are very generally used.

The interests which would be affected by a change in systems in the manufacturing fields, are more important than in any others. In 1910, over 10,500,000 persons were engaged in these fields and the value of their products in 1914 was \$24,000,000,000. Manufacturing processes transform raw materials into finished products of a definite size, shape, capacity or design and in so doing interweave into the very fabric of the products themselves the weights and measures used. A compulsory change in systems would therefore involve changing the products and also, to some extent, the machinery employed in their manufacture. The degree to which the manufacturing field would be affected varies with the class of product fabricated. For bulk products for immediate consumption, such as grain, coal, nitrates, etc., a change in measures is of small moment. In goods for immediate consumption in which the original measure is incorporated as part of the product, such as canned goods, textiles, ready-made clothing, etc., a change in systems would be felt immediately and the effect upon the customs of the consumer would be considerable. In manufactured goods not intended for immediate consumption, like machinery, building material, etc., which require repair and renewal, provision for replacement would have to be made in the old system and a change would be difficult and costly. Finally, as regards products such as weighing scales, precision tools, gauges, screws, etc., which are wholly bound up with the system of measurement, a change would often necessitate the total discarding of the products now in use.

In the field of *foreign trade*, the tendencies are toward establishing a uniform system of weights and measures the world over. The facts indicate, however, that the trade of the world is not carried on more in the metric system than it is in the English and that, on the contrary, the English system predominates. Countries in which the English system is in predominant use, particularly the United States and Great Britain, transact nearly half the export trade of the world, and metric countries transact little more than one-third. With respect to imports, over one-half of the total imports of the world come into metric countries, and less than one-third into English countries. That is, English countries export a greater portion of the total than they import, while metric countries import a considerably larger percentage of the whole than they export, thus indicating that the influence of the English system in world trade is the greater.

The examination of the export trade of Great Britain and the United States with metric countries also indicated that the larger

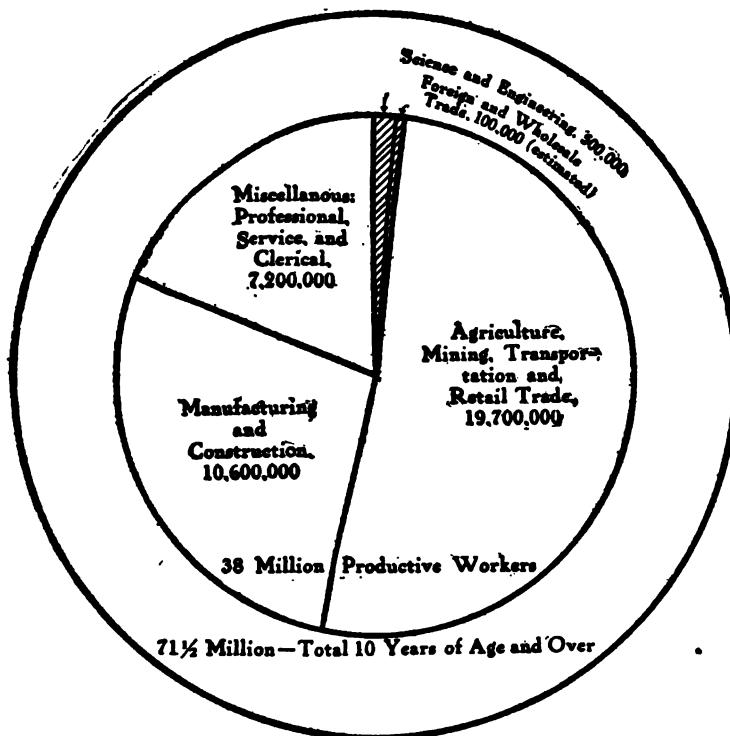
part of the products involved are those in which the English system of weights and measures is most definitely incorporated and that more than half of the exports of the United States go to countries that are not predominantly metric. Furthermore, only a small percentage of the productive effort of the United States shows itself in foreign trade, and in this field also little sentiment in favor of a change has exhibited itself in this country. All these facts, therefore, would militate against a change to the metric system in the United States.

In short it may be said that, with the exception of pure and laboratory science and wholesale trade and with the exception of certain other industries and fields in countries where the compulsory use of the metric system is generally effective, in practically none of the fields of industry and productive activity of major importance—such as agriculture, mining, transportation, retail and foreign trade and the manufacturing industries—in the United States and in other leading countries has the metric system a widely enough established use or position to readily displace the English or other local systems. The facts set forth in the preceding pages indicate further that a compulsory change to the metric system in the United States would doubtless involve many fundamental and serious changes in the industrial and business equipment and practices of the country. It is necessary that these considerations be taken into full account in investigating the advisability of such a change.

The chart on the opposite page illustrates graphically the outstanding features of the situation regarding the use of weights and measures in various fields in the United States as described in the preceding pages. The area of the outer circle, including that of the inner, represents the 71½ million people in the United States in 1910, 10 years of age and over, most of whom are affected by the use of weights and measures as the buying and traveling public. The portion of this 71½ million included in the area of the inner circle, i. e., 38 million, represents the total of productive workers 10 years and over in 1910. This inner area is divided into sectors indicating how the working population was distributed in various specialized fields. The two shaded sectors, i. e., science and engineering and foreign and wholesale trade, represent, as has been pointed out, the only fields interested to any extent in seeing the metric system adopted in the United States. A comparison of these small sectors with the others and also with the complete area of the outer circle gives a rough idea of the relative sizes of fields favoring a change and of those opposed. This presentation is on the basis only of the number of people affected. Other aspects of the situation, such as the value and importance of the products of various fields and the manner in which they are bound up with weights and measures must also be given due consideration.

DIAGRAM V.
DISTRIBUTION OF PRODUCTIVE POPULATION IN SPECIAL FIELDS OF ACTIVITY IN THE UNITED STATES.*

Based on Number of Persons 10 Years of Age and Over affected in 1910.



*For detailed figures see p. 53

PART III

Arguments For and Against the Substitution of Metric for the English System in the United States

In the preceding parts of this report have been outlined the history and present national status of the English, metric and other systems the world over and the application of the English and metric systems to various special fields. Part III presents the leading arguments offered in discussing the proposal to adopt the metric system in the United States. As in all controversies, some of the contentions of both sides are substantiated by fact, others are not. The aim throughout has been to state the position of both parties as completely and with as strict impartiality as possible, leaving the reader to set the contentions, denials and counterclaims on each point side by side and evaluate them in the light of good logic, sound economics, and ascertainable facts. The object in the first two parts of the report was to provide a general basis of facts and economic considerations for this purpose. Together with these, it is thought that Part III will afford a basis for an answer to the major question upon which all discussion of the subject focuses, namely: "Shall the metric system be substituted by compulsion for the English system in this country?" The arguments pro and con present themselves as those based upon (1) the intrinsic merits of each system; (2) the advantages and use in special fields of the metric system as compared with the English system; (3) the practicability of making a compulsory change; (4) the extent and character of the demand for such a change, and (5) a comparison of the metric and English as universal systems.

CHAPTER XI

INTRINSIC MERITS OF THE METRIC AND ENGLISH SYSTEMS

This chapter addresses itself to the question: Is the metric system intrinsically superior to the English? and elaborates with argumentative material the essential characteristics of these two systems briefly described in Part I.¹ Broadly speaking, the intrinsic merits of any system of weights and measures relate to its structure and to the uses required of it. The structure of a system has to do with the manner in which it was devised and the relationship that exists between its various elements. The use of a system has to do with the various needs it is called upon to fill.

The general question of intrinsic merits divides itself into the following specific ones: (1) Are the fundamental units of the metric system intrinsically superior to those of the English? (2) Is the manner of multiplication and division of units in the metric system superior? (3) Are the units in common use in the metric system fewer and are their names more easily learned and retained than those of the English system? (4) Does the simplicity of structure, indicated in the discussion of the three preceding questions, make the metric system more comprehensible than the English? (5) In practical use is the metric system more convenient, more adaptable, and more comprehensive than the English in filling the needs that a system of weights and measures is called upon to fill?

ARE THE FUNDAMENTAL UNITS OF THE METRIC SYSTEM INTRINSICALLY SUPERIOR TO THOSE OF THE ENGLISH?

Metric

Advocates of the metric system contend that the scientific character of the fundamental metric units provides an invariable basis for comparison and for building up a scientific structure, in that the units of capacity and weight are definitely related to that of length and because other scientific units can easily be added.

The manner in which the meter was devised has been examined in detail.² It is still maintained by some metric advocates that in using the circumference of the earth as the basis, an invariable standard of comparison was provided which insures absolute ac-

¹ See pp. 6 ff. and pp. 13 ff.

² See Part I, p. 10.

curacy, and that the English system has no such scientific basis for correcting the basic measure of length.

As has been pointed out,¹ the units of length, weight and capacity in the metric system are supposed to have an exact inter-relationship, i.e., the kilogram was defined originally as the mass of a cubic decimeter of water at maximum density and a liter was to have a capacity such as to contain a kilogram of water or to be equal to a cubic decimeter. This relationship can be expressed as:

$$1 \text{ cubic decimeter} = 1 \text{ kilogram} = 1 \text{ liter.}$$

Metric proponents contend that this correlation between metric measures of length, weight and capacity makes it possible to build up an absolutely scientific structure, using the meter, gram and liter as a basis. In support of this contention, they point to the proposed extension of the metric system to include units of time, electrical resistance, temperature, and intensity of light, as recommended by a commission, appointed by the French Government, which filed its report in Paris, 1913.²

It is urged in this connection that the fundamental units of the metric system are so simply related that one unit is readily converted into another without elaborate computations. It is held that in the English system "complex relationships of the various denominations are such that they are interconvertible only by calculation, whereas in the metric system no such calculation is required, as they are interconvertible by inspection because the metric system 'harmonizes with the world's arithmetical notation,'"³ and that "the correlations established between measures of length, weight and volume, together with the uniform decimal enumeration, tend to facilitate and simplify computations and reduce the necessity of memorizing tables of weights and measures, thus saving time in the school, the office, and the workshop, and simplifying work for all."⁴

English

Proponents of the English system deny that there is any scientific superiority in the fundamental metric units, from the standpoint either of invariableness or of building up an absolutely scientific structure, since there exists a discrepancy between the meter and the length of a terrestrial meridian and between the kilogram and the meter, and because the original intention in the metric

¹ See Part I, p. 13.

² Great Britain. Conjoint Board, Scientific Societies. Metric Committee. Report on Compulsory Adoption of the Metric System in the United Kingdom. February, 1920, p. 9.

³ American Society of Mechanical Engineers. Report No. 927. "Report of Committee Appointed to Discuss the Arguments in Favor of and Against the Metric System," p. 659.

⁴ *Idem.*, p. 632.

system to relate the circumference of the earth to angular and time measures proved impracticable and had to be abandoned.

In denying the truth of metric contentions on this point, English proponents point out that later surveys have shown that the length of a terrestrial meridian was not measured with absolute accuracy when the standard meter was constructed and that, according to our present knowledge, the meter is about one part in five thousand short of its intended length. They contend, in fact, that in any case no absolute basis for comparison can be provided through the length of a terrestrial meridian in that, "owing to the considerable ellipticity of the earth, the relation between the length and the amplitude of an arc is not constant, but varies with the latitude."¹ Again, the unit of measurement used in deriving and expressing the meter was the old French foot, a highly variable and inaccurate standard.² Furthermore, they point out the wave length of light, through the work of Professor Albert A. Michelson, now affords an absolute standard of comparison more permanent than any previously known. Any standard of length, metric, English or other, may now be expressed in terms of it and thus be made reproducible at any time.

In addition, proponents of the English system call attention to the fact that, in basing the fundamental measure of length in the metric system upon the length of a great circle of the earth a more important purpose was supposed to have been served than that of providing an invariable standard of comparison. In its original completeness the metric system divided the day into 10 hours and the circle into 400 degrees in order that one hour difference of time might correspond with 40 degrees difference of longitude as well as 4,000 kilometers of distance, thus correlating linear, angular and time measures. Since it was quickly found impossible to enforce the 10-hour day and the 400-degree circle, and the old sexagesimal divisions had to be retained for both angular and time measures, one of the main purposes in fixing the length of the meter in the manner chosen, English proponents repeat, was found impossible of achievement.

In this connection it is argued also that not only is the relation of the metric system to the great circle of the earth an imperfect and inconvenient one, but the English system possesses whatever advantages may lie in this relation without any of the defects from which the metric system suffers. The longer unit of measure in the English system, the statute mile, is derived, English proponents state, from measures of distance which were based

¹ Great Britain. Conjoint Board, Scientific Societies. Metric Committee. Report on Compulsory Adoption of the Metric System in the United Kingdom, February, 1920, p. 8.

² For a description of the process of deriving the meter, and of the difficulties in obtaining standards see Gould, B. A. Address on the Metric System of Weights and Measures before Commercial Club of Boston, Feb. 18, 1888, pp. 9-15.

by the ancients on the length of one minute of arc of a great circle of the earth, and the English nautical mile, 'universally used in navigation even by metric peoples, is identical with the ancient unit thus derived.¹ The longer English unit of distance is, therefore, related to the terrestrial meridian and at the same time has a convenient relation to the established units of time, the angular division of the circle, and the measures of longitude and latitude, to which even metric countries adhere.

The fact that the original metric time and angular divisions had to be discarded, English proponents continue, contradicts the contention of metric advocates that their system is built upon a scientific foundation. It is denied further that there is a scientific relation between fundamental metric units in other respects. English proponents point out that while the standard kilogram was intended to have a mass equal to that of a cubic decimeter of water at its maximum density, it has since been determined that the kilogram is about one part in thirty-seven thousand in excess of this absolute measure, and that, therefore, a discrepancy exists between the cubic decimeter and the liter, so that for the exact and fine purposes of science, certain corrections must be made in using metric units. With respect to the proposals of the French commission recommending the addition of secondary units to the fundamental metric units now in use, it is pointed out that the ones suggested are not the original metric units of time and angular measure but rather the habitual sexagesimal divisions which do violence to the strictly decimal nature of the metric system as now constituted. In short, English proponents contend, the metric system is neither strictly scientific in its origin nor in the relationship between its fundamental units, nor is it possible to build up a scientific structure upon it without the addition of units which are not based on the meter or which are not decimally related to the metric system.

Moreover, English proponents continue, if a scientific relationship of fundamental units to terrestrial dimensions and to each other is considered of importance in a system of weights and measures, Sir John Herschel, the famous British astronomer, has shown that the basic short unit of length, the foot, is itself quite as closely related to the length of the polar diameter of the earth as the meter is to the meridional circle, and that the measures of capacity and weight, the pint and the ounce, are also derivable from this "geometric foot" with as close approximation as the liter and kilogram are derived from the meter.²

English proponents deny the existence of alleged ease of convertibility between fundamental metric units. "The alleged 'cor-

¹ See pp. 3, 72-3.

² Statement of Sir John Herschel quoted by Warrenner, W. T. Hearings before the House Committee on Coinage, Weights and Measures, 58th Congress, 1st Session, 1904, pp. 84-85.

relation between the measures of length, weight and volume' of the metric system applies only to the relation between the measures of length and the weight of distilled water at a certain temperature; for any other material whatever, recourse must be had to tables of specific gravity, while in the English system reference is made directly to tables of weight per cubic foot, which are certainly just as simple and easily memorized as specific gravities. . . ."¹ There is no ground, therefore, English proponents maintain, for the metric contention that conversions can always be effected by a simple mental process without calculations.

Finally, English proponents urge that in most of the practical work of the world little need arises for relating weight, capacity, and length to one another, and in view of the fact that the relationship between fundamental metric units is not exact, the use of such units holds, in this respect, no advantage over the more practical English units. The high degree of accuracy of their standards emphasized by metric proponents is, they say, a matter of importance chiefly to science. The English system, English advocates maintain in conclusion, is fundamentally practical and natural, because it is related to lengths of various portions of the human body and composed of handy weights and ready measures of capacity, and for every-day purposes such attributes are of much greater importance than those claimed for the fundamental units of the metric system.²

IS THE MANNER OF MULTIPLICATION AND DIVISION OF UNITS IN THE METRIC SYSTEM SUPERIOR TO THAT IN THE ENGLISH?

Under this heading two questions call for discussion: first, the facility with which multiplication and division can be carried on in the metric and English systems and the bearing of decimals and common fractions on ease of computation, and, secondly, the relative merits of using decimals only as against using both decimal and fractional divisions.

GENERAL FACILITY OF USE

Metric

Advocates of the metric system maintain that the strictly decimal multiples and subdivisions of their system are superior to the binary and duodecimal divisions of the English system.

In contending that decimals, which are operated by a simple shifting of the decimal point, are easier to work with and to understand than common fractions, which require the actual ma-

¹ American Society of Mechanical Engineers. Report No. 972, p. 633; also *idem.*, p. 704. See also paper by Charles H. Tutton. Proceedings Engineers' Society of Western New York, December, 1902.

² Toledo Scale Company, *Toledo System*, April 3, 1920; see also Report of John Quincy Adams to Congress, 1821, p. 70.

nipulation of the integral numbers involved, metric proponents point out that the decimal relationship between a smaller and a larger unit of the same measure in the metric system makes for ease in translating from one to the other, while in comparison operations in the English system are cumbersome. "Values expressed in any one of the different metric units," metric proponents repeat, "are translated into values expressed in any other unit with great facility and usually by simple inspection, i.e., without calculation. For instance, 4 centimeters equal 40 millimeters, or .4 decimeter, or .04 meter, or .004 decameter, or .0004 hectometer, or .00004 kilometer; and all these relations, after very little familiarity with the system, are instantly known, almost without mental effort." Metric proponents suggest a comparison of this simplicity "with the work required, for instance, to determine the value of $17/32$ inch in fractions of a foot, yard, rod or mile,"¹ and ask whether such a decimal as .655 is not easier to comprehend than its corresponding fraction $1129/1728$.²

Finally, it is pointed out by metric proponents that the metric system, because of its uniform decimal nature, is especially well adapted to slide-rule computations and other mechanical calculating devices, all of which are inapplicable to common fractions.³

English

In general, English proponents deny metric claims of superiority for decimals over common fractions, but point out that so far as the use of decimal divisions or multiples of units is concerned, such decimalization can be applied to the English system just as conveniently as to the metric. This, they continue, finds many illustrations, as in mechanical work and in the textile industry, in both of which the English units used are habitually decimalized where decimals have been found by experience to be convenient. English answers to metric contentions on this point follow the lines, first, that decimals are not easier to work with because errors often occur through the misplacing of the decimal point, in which respect fractions are better; second, that simple fractions—and these are the ones most commonly used in the English system—give a clearer mental picture and are more easily understood than are the equivalent decimal fractions; and third, that, while English units have a binary and duodecimal relationship making for convenience and adaptability to various needs, the strict decimal relationships in the metric system make for rigidity, inflexibility and lack of convenience and adaptability.

English proponents, in support of their contention that decimals are not easier to work with because errors commonly occur through

¹ American Society of Mechanical Engineers, Report No. 972, p. 634.

² Miller, Fred J. Transactions, American Society of Mechanical Engineers, v. 24, p. 521; see also, Hearings before House Committee on Coinage, Weights and Measures, 58th Congress, Testimony of Dr. Alexander G. Bell, pp. 264-268; also, Hearings 56th Congress, pp. 197-209.

³ American Society of Mechanical Engineers, Report No. 972, pp. 632-634.

the misplacement of the decimal point, cite a test problem which was submitted to a number of workmen in a machine shop using the metric system. This problem "was submitted to seven draughtsmen and designers, some of them of more than average attainments, and all of them thoroughly familiar with the metric system. . . . The correct result was arrived at by only three of the seven men. . . . The difficulty lay in the correct location of the decimal point; with one exception all had the correct numerals, but the men were apparently lost in a maze of decimal figures. The location of the decimal point varied by as much as six places." By way of comparison, the same problem with equivalent values in English units was then given out and the correct result was arrived at by six out of the seven men in an average of two-thirds the time necessary to solve it in the metric system.¹ Such a situation as this, English advocates maintain, is typical of the difficulty experienced by the average person in working with decimals. "Long and arduous training is necessary to teach the mind to think in decimals. This means that if the metric system is to be applied to the affairs of every-day life, more time must be spent in primary education. Learning the tables is not learning the system. Until the various units can be objectified and combinations visualized, the student's knowledge of the system is but little deeper than a parrot's knowledge of grammar."² Mr. Charles H. Tutton, in speaking before the Engineers' Society of Western New York in 1902, made the following observation in this connection:

The most difficult part of mathematics for students to grasp is decimals, and wherever possible they are avoided by business men; and educated gentlemen though you are, it would be perfectly safe to assert that there is not one of you who could not easily be made to stumble over this mode of calculation.³

In answer to the metric contention that such units as millimeters, centimeters, decimeters, meters, decameters, hectometers and kilometers are easily translated from one unit to another, English advocates reply that the purported facility of change from one of these to another "is not to be compared with . . . the avoidance of errors due to the misplacement of the decimal point, which is the great advantage of the English system."⁴ They point out, also, that the supposed difficulty involved in determining the value of $17/32$ inch in fractions of a foot, rod, or mile, is a wholly theoretical difficulty, in that "the particular example given . . . is one which might be given to a child as an exercise in arithmetical computation, but is one which is practically never to be met with in a lifetime of experience by a mechanic, machine designer or engineer. A machinist could easily measure

¹ Hess, Henry. Letter to *American Machinist*, October 16, 1902.

² Toledo Scale Company. *Toledo System*, April 3, 1920, p. 3.

³ Proceedings Engineers' Society of Western New York, December, 1902, quoted American Society of Mechanical Engineers, Report No. 972, p. 704; see also, Hearings, etc., 58th Congress, *op. cit.*, p. 205.

⁴ American Society of Mechanical Engineers, Report No. 972, p. 635.

1 foot $17/32$ inch, but what probability is there that he would ever have to record the dimension as $1-17/384$ or 1.04427 ft.?"¹ In comparison with such a problem, English proponents present a problem in the metric system, which, they say, is one much more likely to be met in every-day life, viz., "what is the side of a square whose area is ten hectares? Answer: 316.628 meters."²

They submit further that it is wholly misleading to compare a fraction such as $1129/1728$, which is never met with in average practice, with its corresponding decimal $.655$. Compare rather, they contend, the following common fractions, found in regular practice, with their decimal equivalents. Which, they ask, gives a clearer mental picture?³

$$\begin{aligned} 1/8 &= .125 \\ 1/32 &= .03125 \\ 1/60 &= .01667 \end{aligned}$$

They also give as an example of the clearer mental picture presented by fractions, another problem encountered in actual practice.⁴

A conveying belt 100 feet long, running 400 feet per minute, delivers 20, 40, 60, 80 or 100 tons of 2,000 pounds per hour. What is the load on the belt for each rate of delivery?

SOLUTION BY FRACTIONS

Tons per hour = T	20	40	60	80	100
Tons per minute = $1/60$ T.	$1/3$	$2/3$	1	$1-1/3$	$1-2/3$
Load on belt = $1/4$ of $1/60$ T.	$1/12$	$1/6$	$1/4$	$1/3$	$5/12$
Load on belt in pounds	$166-2/3$	$333-1/3$	500	$666-2/3$	$833-1/3$

SOLUTION BY DECIMALS

Tons per hour = T	20	40	60	80	100
Tons per minute = $1/60$ T.	.3333	.6667	1	1.3333	1.6667
Load on belt = $1/4$ of $1/60$ T.	.0833	.1667	.25	.3333	.4167
Load on belt in pounds	166.7	333.3	500	666.7	833.3

Where any aids to calculations are employed, such as slide-rules, logarithms, or calculating machines, they say, a strictly decimal system may have some advantages, but for the mass of the people who in the ordinary operations of their business perform their calculations by mental arithmetic or ready reckoners, a system with a variety of units connected by such intervals as 2 and multiples of 2 is the better.⁵ Furthermore, "for slide-rule and logarithmic computations a short table of decimal equivalents of binary fractions may be printed on the back of the slide-rule, eliminating the chances of error in computing these equivalents."⁶

With regard to the whole question of ease in calculation in general, English proponents point out that the extensive and growing

¹ American Society of Mechanical Engineers, Report No. 972, p. 635.

² *Idem.*, p. 635.

³ American Society of Mechanical Engineers, Transactions, v. 24, p. 448.

⁴ American Society of Mechanical Engineers, Report No. 972, p. 697.

⁵ Atkinson, L. B. *Journal of the Institution of Electrical Engineers*, February, 1918, p. 124.

⁶ American Society of Mechanical Engineers, Report No. 972, p. 635.

use of calculating machines for all kinds of work involving computation has put the English and the metric systems on an equal footing and made any question of intrinsic superiority in this connection quite beside the point, except as regards the ordinary person and his needs, for whom the familiar English system is vastly superior.

Summing up their contentions that simple fractions are easier to work with than decimals, the following citations from such authorities as John Quincy Adams and Napoleon I represent the position of the advocates of the English system.

It appears also not to have been considered that decimal arithmetic, although affording great facilities for the computation of numbers, is not equally well suited for the division of material substances. A glance of the eye is sufficient to divide material substances into successive halves, fourths, eighths and sixteenths. A slight attention will give thirds, sixths and twelfths. But divisions of fifth and tenth parts are among the most difficult that can be performed without the aid of calculation. Among all its conveniences, the decimal system has the great disadvantage of being itself divisible only by the numbers two and five. The duodecimal system, divisible by two, three, four and six, offers so many advantages over it, that while the French theory was in contemplation, the question was discussed whether the reformation of weights and measures should not be extended to the system of arithmetic itself, and whether the number twelve should not be substituted for ten, as the term of the periodical return of the unit.¹

Napoleon had the following to say on this point:

Twelve has always been preferred to 10 as divisor, because 10 has but two factors, 2 and 5, while 12 has four, 2, 3, 4, and 6. I can understand the twelfth part of an inch, but not the thousandth part of a meter. . . . La Place himself assured me that if all the objections I had made to it had been pointed out to him before its adoption, he would have recognized its defects and given it up. . . . Finally they used Greek roots, and that augments the difficulties. . . . The new system of weights and measures will be a subject of embarrassment for many generations. It is a tormenting of the people for mere trifles.²

MIXTURE OF BINARY AND DECIMAL FRACTIONS

Metric

Metric proponents point out that the exclusive use of the metric system would avoid the mixture of decimal and binary fractions now in common use in machine shops, which mixture requires frequent conversion of common fractions to decimal equivalents and reference to printed tables.³ As an example of the kind of difficulties it is claimed would be avoided, the following is cited:

A hole is $1\frac{3}{32}$ inches diameter; a piece is to be turned to fit it with .003 inch clearance; what is the diameter of the latter piece? By

¹ Report of John Quincy Adams to Congress, 1821, p. 71.

² Memorandum for use of a History of France under Napoleon written at St. Helena by General Comte de Montholon, vol. 4, pp. 213-18. Quoted in United States. 58th Congress. Hearings before House Committee on Coinage, etc., p. 81-2.

³ American Society of Mechanical Engineers. Report No. 972, p. 638.

reference to a table we find $1\frac{3}{32}$ inches = 1.09375 inches, and subtracting .003 inch we have 1.09075 inches. A parallel example in the metric system would be: Hole 29 millimeters diameter; diameter of pin to fit with .06 millimeters clearance equals 28.94 millimeters, and the size is thus obtained immediately, without a table and by mental calculation. In other words, absolute dimensions for fine fits can be expressed clearly and with greater precision (in the metric system) than is the case with our system, and much figuring in shop and drafting room thereby saved.¹

Changing binary to decimal fractions and then changing back again for the result, would be abandoned, together with all the sources of error to which those processes are liable.²

English

The English answer to this contention is, first, that both decimals and common fractions are used in the English system as a matter of choice; secondly, that common fractions could be dispensed with in the English system if that were thought desirable,³ but that, thirdly, as already pointed out, the use of binary and duodecimal subdivisions fills an undoubted need both from the standpoint of easy comprehension and of the every-day uses of the people.

Answering the statement of metric proponents that extreme difficulty is experienced in changing from common fractions to decimals, and using the same problem presented by metric advocates, English proponents reply as follows:

The English system avoids the use of decimal and binary fractions whenever the designer or user of the unit chooses to use either one fraction or the other in his work. For instance, a superintendent of a machine shop, wishing to order a pin to fit a hole which is $1\frac{3}{32}$ inch diameter with .003 of an inch clearance, would, by reference to a table on his desk, or to the table stamped on his micrometer caliper, obtain the diameter of the hole in decimals, viz., 1.094, and the dimension $1.091 = 1.094 - .003$ would be given to the workman, or a gauge would be furnished him to work with. In other words, absolute dimensions for fine fits can be expressed in one unit just as well as in the other.⁴

English proponents maintain in short that the use of both binary and decimal fractions in the English system is an advantage in that it serves the needs of computations where necessary and also the needs of the great bulk of every-day uses involving binary and duodecimal relations.⁵ A strictly decimal relationship makes for inflexibility and lack of adaptation in a system, while binary and duodecimal relations meet an undoubted need of the human mind which a strictly decimal system cannot in any measure fill.

The following quotation sums up the position of advocates of the English system on this point:

¹ American Society of Mechanical Engineers, Report No. 972, pp. 638-40.

² *Idem.*, p. 632.

³ *Idem.*, p. 653.

⁴ *Idem.*, p. 639.

⁵ Towne, Henry R., "Proceedings of the American Society of Mechanical Engineers," 1906, p. 870.

It is a common error to confound the "metric system" with the "decimal system," but the former is a system of *standards* (of length, weight and volume), whereas the latter is a system of *notation*, applicable to any system of measures. Decimal notation has great and recognized advantages for certain usages, especially in calculations and in recording transactions in money, but never has been and never will be preferred in most of the common transactions of daily life. The human mind resorts naturally to *binary* division, that is, into halves, quarters, eighths, etc., and no legislation can change this human trait. Decimal division can also be availed of when desired and has long been applied to the foot and inch, as well as to the meter. If decimal notation were the only object sought, it could be had without changing our present *standards*, and such change might well be considered in an effort to simplify our existing "tables," especially in connection with the effort, long strongly urged, to bring the British and American standards into complete uniformity by eliminating the few divergencies which now exist.¹

ARE THE UNITS IN COMMON USE IN THE METRIC SYSTEM
FEWER AND ARE THEIR NAMES MORE EASILY LEARNED
AND RETAINED THAN THOSE IN THE ENGLISH SYSTEM?

There is very little agreement among advocates of the metric system and those in favor of the English system as to the number of units in common use in the respective systems. The contentions based upon the character of the names of the units, however, are more readily evaluated.

CHARACTER OF NAMES OF UNITS

Metric

Metric proponents assert that the names of the metric units, in view of the fact that they are in keeping with the decimal relationship which each secondary unit holds to the primary unit of length, weight or capacity, are more easily learned and less open to confusion than the English units, and that they "can be readily abbreviated into terse words or monosyllables, adapted for popular use, but retaining the significance of the original."² The prefixes "deci," "centi," and "milli," for instance, when added to the basic units meter, liter and gram, indicate respectively units 1/10th, 1/100th, and 1/1000th, as large as the basic one; and the addition of the prefixes "deca," "hecto," "kilo," and "myria" indicate similarly the larger units respectively, 10, 100, 1000 and 10,000 times as large as the meter, liter or gram.

English

Advocates of the English system, on the other hand, argue that the names of English units are mostly monosyllables and differ sufficiently in sound to make them distinct, while those of the metric system are mostly polysyllabic, quite similar in sound and thus readily confused. They maintain that for this reason the

¹ Towne, Henry R. *Industrial Management*, June, 1920; see also, Report of John Quincy Adams to Congress, 1821, p. 81.

² American Society of Mechanical Engineers, Report No. 972, p. 650.

names of English units are more easily apprehended and more readily retained than are those of the metric units.

In answer to the claim of the pro-metrics, that the standard terms for metric measures are susceptible of abbreviation, proponents of the English system point to the experience of France where, in a period of more than one hundred years, the people have not adopted such abbreviated terms.

NUMBER OF FUNDAMENTAL UNITS IN COMMON USE

Metric

Metric proponents present lists of units in general use in the metric and English systems, and on the basis of such lists assert that the number of fundamental metric units in common use is fewer than the number of English units. One such table assigns a total of 16 units for the metric and 33 for the English system.¹

English

English proponents, in denying the metric contention on this point and maintaining that the commonly used units of the English system are fewer than those of the metric system, assert, first, that lists such as those just mentioned are not fairly representative, in that on the English side units are included which have become obsolete or are little used except in special fields, while on the metric side certain real and distinct metric units, such as the decimeter, are not counted as distinct units but as multiples of smaller units, thereby making the number of metric units in use appear smaller than is actually the case. In substantiation of their position regarding the comparative number of units in both systems, English proponents present a list which, omitting fractional units and those infrequently used in the English and metric systems, shows a total of 30 units in common use in the metric system and 19 in the English system. In connection with this table,² proponents of the English system say:

From the table of English measures have been omitted those measures that are either obsolete or obsolescent, and only used by a small fraction of the population engaged in special trades. Among those omitted are the chain, link and rod, which are never used except by some engineers in surveying old boundaries, the foot having generally taken their place; the furlong and the league, which are obsolete; the point and the line, which are used only by printers; the fathom, used by sailors; the hand, used by horse dealers, and the mil, used in electrical engineering work, being a thousandth part of an inch. From measures of surface have been omitted the square rod and rood, which are obsolete, and the circular mil, used only in electrical wiring calculations. In measures of volume there are omitted the cord, used in measures of firewood only; the perch, used by masons; the gill, hogshead and bar-

¹ Atkinson, L. B., *op. cit.*, pp. 121-124; see also American Society of Mechanical Engineers, Report No. 972, pp. 663-665.

² *Idem.*, pp. 658-60.

rel, tierce, etc., which are practically obsolete measures of liquids, also the pint, which is simply half a quart; and the peck, which is quarter of a bushel and used only by green grocers. The fluid drachm and fluid ounce are used only by druggists for liquid measures. In the tables of weights there are omitted drachms, quarters, hundredweight, stone, which are obsolete measures in the United States. The Troy and Apothecaries' Weights are omitted, with their pound, ounce, pennyweights, grains, scruples and drams, because Troy Weight is only used in measuring silver and gold, and Apothecaries' Weight only for prescriptions, so that nineteen terms are all that are really needed by the English-speaking races for all commercial and manufacturing purposes.¹

In another table² the fundamental and universally used units in the English system are listed as follows:

<i>Length</i>	<i>Surface</i>	<i>Volume</i>	<i>Weight</i>
inch	sq. inch	cu. inch	grain
foot	sq. foot	cu. foot	ounce
yard	sq. yard	cu. yard	pound
mile	sq. mile	quart	ton

With respect to this list English proponents observe:

These are all the units that need be used in computations by the mechanic and engineer, fifteen in all.

The number of these units may easily be reduced, for mechanics and engineers scarcely ever use the yard or the square yard. The cubic yard is used as a measure of earth and rock, by old usage, but a new unit of 100 cubic feet might, with advantage, be substituted for it. So also the ounce and grain might be abandoned and decimal divisions of a pound used instead.

The mechanic and engineer would then have only nine fundamental units to memorize, viz., inch, foot, mile, square inch, square foot, cubic inch, cubic foot, pound, ton.

The nine units form a system superior in every way to the metric system. Any one of them may be used with binary or decimal subdivisions as desired.³

English proponents point out finally that the multiplicity of units charged against the English system is due to the fact that the teaching of the system has been based on educational practices which vary from locality to locality. Thus many units and relationships are continued which are obsolete so far as general practice is concerned.

DOES THE SIMPLICITY OF STRUCTURE BROUGHT OUT UNDER THE THREE PRECEDING QUESTIONS MAKE THE METRIC SYSTEM MORE COMPREHENDIBLE THAN THE ENGLISH?

Metric

Summing up the contentions set forth under the headings of the relationship of fundamental units to source of origin and to one another, the multiplication and division of units, and the number

¹ *Idem.*, pp. 660-62.

² *Idem.*, p. 674.

³ *Idem.*, p. 674.

and names of units, metric proponents picture the ideal system of weights and measures as one that is constructed to have the smallest possible number of units, simple ratios between the units, and a simple correlation between the units of length, capacity, and weight, i.e., the simpler the structure, they contend, the more readily will the system be comprehended. The metric system, they insist, with its decimal and scientific correlations, meets these ideal requirements. It is simple in structure and its units are easily convertible, being scientifically related and divided into tenths and multiples of ten; the units are few and their names are easily learned, for which reasons, they say, the whole system is more readily comprehended by the average person than is the English system.

English

English proponents argue in the first place that simplicity of structure is not necessarily synonymous with easy comprehensibility. Their contention is that a system cannot be considered ideal unless its units are of handy size and unless the names of the units are brief, are easily associated with every-day experience and are readily distinguished one from another. Admitting that a system may be very simple and logical in structure, they still contend that unless the elements are familiar and readily visualized and associated, the system will not necessarily be easily comprehended. In this connection they point out that the metric system lacks any intimate association with every-day experience while the English system is interwoven with it at every turn.¹

It is contended ² that the English system, even though possibly not so simple in structure in some respects, is intrinsically more comprehensible than the metric system because it has (1) a smaller number of units, discarding those that are obsolescent; (2) because binary subdivisions are more quickly comprehended by the ordinary mind than decimal subdivisions; (3) because the names of the units are more easily memorized, and (4) because the two units of length, viz., the inch and the foot, and the binary subdivisions of the inch, give a clearer mental picture to the average man than units with such prefixes as milli, centi, deci, deca, hecto, kilo, etc. Furthermore, such simple units as the inch, foot, yard and mile may be used with binary or decimal subdivisions as desired.

With respect to the contention that the calculator finds the metric system easier to comprehend and to use than the English system, English proponents repeat ³ that at least 90% of the people of any country are more concerned with mental arithmetic than with written calculations, and that for this 90% the binary rela-

¹ See p. 6.

² American Society of Mechanical Engineers. Report No. 972, pp. 676-78.

³ Atkinson, L. B., *op. cit.*, p. 124.

tionships, easily associated names and handy units of the English system make it much more easy to comprehend than the metric.

It is observed also by English advocates that comprehensibility, although important, is only one of the important characteristics an ideal system of weights and measures must have. The ideal system must be convenient, adaptable, and comprehensive as well. The dimensions of the English units, they maintain, are more convenient than the metric for practically all purposes of measurement. Again, a simple structure, such as the metric system purports to be, may be not nearly so adaptable as a more complex one nor yet so comprehensive in filling the needs to which a system of weights and measures must be put.

IS THE METRIC SYSTEM AS COMPARED WITH THE ENGLISH
SYSTEM MORE CONVENIENT, MORE ADAPTABLE AND MORE
COMPREHENSIVE IN FILLING THE NEEDS THAT A
SYSTEM OF WEIGHTS AND MEASURES IS CALLED
UPON TO FILL?

Metric

As for convenience, metric proponents contend that those elements of their system which make for simplicity likewise make for convenience, viz., uniform decimal and scientific relationships between the units. They assert also that their system has proved to be readily adapted to mechanical and other needs and comprehensive in filling the requirements made of it.

Dimensions of units, they say, are found convenient or inconvenient according to experience¹ and it has been shown that the metric system can be conveniently used for any mechanical purpose; the millimeter for ordinary machine construction, the centimeter and meter for building construction, and the kilometer for all other distances which, under the English system, are now usually expressed in rods or miles. Examples are given to show that absolute dimensions for fine fits in mechanical work can be expressed clearly and with precision in the metric system, in that metric micrometers are graduated to read directly to the .01 millimeter and no calculation is necessary.² In applying the metric scale for measurements, it is further urged, the user is not hampered by the necessity of preserving the distinctions between inches, feet, etc., or referring to the corresponding symbols. For all ordinary mechanical drawings, pro-metrics say, the millimeter is well adapted, rarely requiring the use of decimal or fractional figures; and as no symbols are needed, the chance for misinterpretation or error is less than with the English system, where feet may be confused with inches and vice versa.

¹ American Society of Mechanical Engineers. Discussion accompanying Report No. 972, pp. 522-528.

² American Society of Mechanical Engineers. Report No. 972, pp. 638-40.

Pro-metrics point out also that there is no distinct nomenclature to express English units between pound and ton or between yard and mile, whereas the metric system contains units of various grades without any such break. They maintain that the metric system is now the usual standard with chemists, physicists and scientists the world over and is generally considered to be best and most convenient for scientific work; that it is used in medicine, pharmacy and other professions involving accurate weighing and measurement of small quantities; and that many hospitals record their patients' physical measurements, including height, in centimeters. These facts, they conclude, demonstrate the fitness of metric units for filling various needs.

English

English proponents maintain, on the contrary, that the organic growth and selection of the fittest units in the English system make it infinitely better adapted to different uses than the metric system. It is not what one is used to, they say, that determines convenience, so much as what is handy. A unit may be considered inconvenient when it is very much greater or smaller than the object which it is used to measure, because it is then necessary to use a fractional figure or too many figures in expressing dimensions.

The English system, it is maintained, provides units of length, etc., admirably adapted to every purpose in measuring: the inch, with its binary or decimal subdivision, as may be preferred, for machine construction; the foot, for all dimensions in building construction up to any number of thousand feet (the foot takes the place of the usual French measures mentioned, the meter, the centimeter and decimeter), and the mile for all great distances. The yard is used chiefly as a measure of length for measuring cloth, just as the *aune*, an old non-metric measure, is used in France. For measures of length, therefore, the three units, inch, foot and mile, cover all requirements better than the five units, millimeter, centimeter, decimeter, meter and kilometer. So far as machine shop practice is concerned, examples are given to show that absolute dimensions for fine fits can be better expressed in the English system than in the metric.¹ "If a micrometer reading to .01 millimeter," English advocates contend, "is better than one reading to .001 inch, so also is one reading to .0001 inch better than one reading to .01 millimeter, and such micrometers are in daily use in tool rooms on work requiring this degree of refinement."² For the purpose of indicating progressive sizes in shafting or piping, binary subdivisions are better adapted than are decimal subdivisions, since a progression in sizes follows more

¹ American Society of Mechanical Engineers, Report No. 972, p. 639.

² *Idem.*, p. 641.

conveniently the line of doubling the fractional part of the next lower size than the line of multiplying it by five or ten.

On the other hand, English advocates point out, the units offered by the metric system are based not upon any considerations of natural convenience but upon an arbitrary division on the basis of ten. None of them owes its existence to the fact that it is particularly adapted to any practical measuring use. The meter, it is true, is comparable to the yard, but the latter is used little outside of measuring cloth and there is no metric unit corresponding to the much-used inch or foot. The nautical mile, equal to 1.853 kilometers and universally used, cannot be replaced by the kilometer, because the former is based on a rational and convenient relation to divisions of longitude, latitude and time. Sixty nautical miles are equal to one degree of the earth's circumference at the equator, and therefore one nautical mile equals one minute of arc.

The English pound, it is maintained further, is the handiest unit of weight used in any system. That it has been chosen in the process of natural selection is evidenced by the fact that primitive races have invariably chosen a weight of about 16 ounces as a standard. A pound to a Titan might seem a very small thing; to an ant it undoubtedly seems like an inconveniently big thing; to man it is a convenient standard by which to gain a conception of the weight of larger and smaller things which he cannot otherwise easily grasp. The pound naturally subdivides into halves and quarters, and the ounce well complements these subdivisions. On the other hand, the unit of weight in the metric system is the kilogram, equal to 2.2046 pounds. That this unit is an unhandy one, because too large, is illustrated by the constant use in metric countries of the half kilo, which is called a pound in every-day retail transactions in France, Germany, Belgium, Italy, Switzerland, and other metric countries.

A similar handiness of size is claimed for English liquid measures such as the pint and the quart. For liquid commodities ordinarily purchased in larger quantities, such, for example, as gasoline, there is the gallon, a unit so indispensable that the advocates of the metric system have in some countries been compelled to destroy the rigidly decimal character of their system by adopting a "metric gallon" of 4 liters. The liter, which is the metric unit of capacity, is approximately a quart. The next smaller unit is the deciliter, which is somewhat less than the gill, long ago abandoned by the users of the English system. The next unit larger than the liter is the decaliter, nearly a barrel. For the purposes of every-day life the liter is the only convenient metric capacity unit. Users of the metric system are, therefore, compelled to resort to multiples and fractions of liters, and it is

significant that the fractions so resorted to are not decimals, but halves, quarters, etc. In short, from every angle, the metric system is devoid of the English system's handiness and convenience; its units are either too large or too small for general every-day requirements.

In this connection, English proponents point out again that while decimal subdivisions and notations are convenient for computations, there is unquestionably a need in human nature for ordinary fractional subdivisions, especially the binary subdivisions of repeated splitting into halves, which have their widest application in every-day affairs and in mental operations as against written calculations. The housewife does not think in terms of buying so many tenths of a pound of butter, but if she does not need a full pound she gets a half pound or a quarter, and this is only one of many illustrations that could be given indicating how the English system is adapted to the needs of every-day life. The metric system cannot fulfil the need for binary subdivisibility, while the English system has been successfully used with both the binary and the decimal division.

As for adaptability, a simple structure may be not nearly so adaptable as a more complex one. By way of illustration English proponents compare the simple cell structure of the amœba, the lowest form of animal life, with the structure of man, the highest form. The single-cell amœba, they point out, is simpler in structure, but the complex organization of man is much better adapted to meet the exigencies of present-day civilization. The English system, they continue, deeply rooted as it is in human psychology and organic growth, is more convenient and is better adapted to present-day needs than is the rigidly constructed metric system.

Summing up, English proponents maintain that the English system is intrinsically superior to the metric because its fundamental units, such as the inch, foot, pound, ton, quart, gallon, have developed from the eternal process of a natural selection of fittest units and not as the result of a rigid inflexible plan; because it multiplies and divides its units not only decimally to meet certain limited needs but also binarily and duodecimally to meet other and much more extensive needs; because the character and names of its units are so tied in with every-day experience that they are readily learned and retained; and because the features just mentioned make the English system, as compared with the rigid and inflexible metric system, much more comprehensible to the average mind, and more convenient, adaptable and comprehensive in filling the needs a system of weights and measures is called upon to fill.

CHAPTER XII

ADVANTAGES AND USE OF THE METRIC AS COMPARED WITH THE ENGLISH SYSTEM IN SPECIAL FIELDS

The arguments discussed in the preceding chapter are based upon certain inherent abstract merits claimed for the metric system as compared with the English. After the questions therein involved have been settled, there arises the further question as to whether the metric system should be adopted in the United States, because of its already extensive use in other countries, or because of any demonstrated or possible practical advantages to be derived from its use in certain special fields of activity as compared with the English system. The present chapter will endeavor to sum up the contentions surrounding the question: Would a change to the metric system in the United States be beneficial in educational and scientific work and in engineering; in agriculture, mining and transportation; in manufacturing industries and domestic trade; and in foreign trade, because of its advantages in these fields, or because of the extent of use it has already achieved in them in the United States and in the rest of the world?

IS THE METRIC SYSTEM OF ADVANTAGE AND IN EXTENSIVE USE IN CALCULATIONS, EDUCATIONAL WORK, TECHNICAL LITERATURE, ETC.?

Metric

Metric proponents assert that, in view of the intrinsic merits claimed for the metric system in the preceding chapter, and in view of the experience of those who have used the metric system in the schools and in all work involving computations, as well as in technical literature, the adoption of that system in these connections would make possible a great saving of time and effort for students and workers in offices, laboratories and work-shops, and would enhance the usefulness of the technical literature of all countries by making it universally intelligible. This is to be expected, they say, because, as described in the preceding chapter, the correlations established between measures of length, weight, and

volume in the metric system, together with the uniform use of the decimal notation in it, tend to facilitate and simplify arithmetical work and computations generally, and reduce the necessity of memorizing tables of weights and measures, which in the English system, they maintain, are excessively complicated.¹

The advantages of the metric system in saving time and effort in all work involving calculations are obvious, metric proponents say, when the intrinsic merits of the system, as set forth in the preceding chapter, are considered.

The time which might be saved in primary education through the use of the metric system is variously estimated by its advocates as from two-thirds of a year to three years in the life of every school child.² Dr. Joseph V. Collins, a teacher and mathematician of Wisconsin, states his opinion³ that by the use of the metric system children would be able to have on an average one full year more of education because "they would not be driven out of school by the terrible inroads upon their interest in school work made by dull, and to them, impossible, arithmetic." A statistician of the United States Bureau of Education is quoted as saying before a congressional committee that the use of the metric system in teaching arithmetic would obviate the need of teaching denominate numbers, which he estimates take one-twelfth of a child's time at school, amounting to two-thirds of a year over the whole course.⁴ It is cited that of 221 head-masters in England who reported upon the subject in 1903, 212 expressed unreserved support of the metric system, believing its introduction would greatly economize school time;⁵ and a committee recently appointed by the British Prime Minister to inquire into the position of natural science in the educational system of the British Isles is quoted as stating "that the present chaos of British weights and measures . . . causes great waste of time and confusion of thought which are strong educational reasons for the adoption of the metric system."⁶

Metric advocates say, in short, that much time and effort would be saved for all classes of people in learning weights and measures through the adoption of the metric system, because of the ease with which it is claimed that system may be comprehended and used.⁷

¹ American Society of Mechanical Engineers. Report No. 972, p. 632; also, United States. Hearings before House Committee on Coinage, etc., February, 1902, pp. 3, 19-22; also Hearings, 58th Congress, pp. 264-268.

² "America's Demand for a Fair Measure Deal." *Grip*, October, 1920, pp. 11-12. See also, World Trade Club, Pamphlet, "Meter-Liter-Gram in World Trade and World War," p. 9.

³ *Scientific Monthly*, December, 1915.

⁴ United States. Hearings before House Committee on Coinage, Weights and Measures, 1902, Testimony of Summers, A., pp. 76-81.

⁵ Stubbs, A. J. *Journal of Institution of Electrical Engineers*, v. 56, 1918, p. 131.

⁶ World Trade Club. Pamphlet, "Meter-Liter-Gram in World Trade and World War," p. 9.

⁷ See p. 136.

The advantages to be derived from the use of the metric system in technical literature are emphasized by metric proponents as part of the advantages which would flow from having a uniform system in use the world over.¹

English

As developed in the preceding chapter, English advocates deny that the English system is difficult to use in computations as compared with the metric, and point out again that the current extensive use of decimals in connection with English units in modern calculations has made the work of computations in that system as easy as in the metric system.² The rapid development and extensive use of calculating machines, slide-rules, etc., has, they say, enabled computations of whatever kind to be made with equal ease in any system, so that the metric and English systems have in present practice been put on the same footing in this regard. Furthermore, they point out, the adoption of the metric system in the United States would lead to the use of a *mixture of systems*, involving the necessity for conversions between them, which would mean that the labor of calculations would be still further increased.³

Supporters of the English system deny that there would be any saving of time through the more general use of the metric system in the schools, and point out that the actual result would be a great confusion owing to the necessity of teaching two systems side by side during the transition period.

The following from a report of the American Society of Mechanical Engineers⁴ is cited in this connection:

It has been found, upon investigation by the Bureau of Education of the United States and the Select Committee on Weights and Measures of the House of Commons in Great Britain, that a year of school life of a child could be saved through replacing the customary weights and measures by the metric system. If this conclusion is based on the theory that the old units are to continue, as all experience shows they will, the conclusion is nullified and reversed—the children will have an additional system to learn and their labors will be increased and not diminished.

¹ See p. 201.

² See p. 130.

³ Halsey, F. A. "Weights and Measures of Latin-America," American Society of Mechanical Engineers. Report, December, 1918, p. 11; also, *American Machinist*, November 27, 1902, p. 1725.

⁴ Report No. 972, Appendix XII, "Action of Cincinnati Manufacturers on the Metric System," p. 698, reprinted from the *American Machinist*, November 27, 1902, p. 1725. In the same report, Appendix IX, pp. 691-95, appears another article. "The Metric System: A Big Job for a Literary Engineer," republished from *Engineering News* of February 19, 1903, which throws an important sidelight on this situation. This article explains the tremendous difficulties to be encountered in forcing the large populations of the United States and England to forget or mentally translate into metric units facts and figures which they have stored in their memories and which are based on the inch as the unit of measurement. It further emphasizes the necessity of two kinds of literature to be produced and studied during the transition period,—(1) transition literature, and (2) metric literature,—and shows the tremendous difficulties involved in this.

In answer to the contention that the teaching of weights and measures now takes up considerable time, English proponents point to the curriculum of the elementary schools of New York¹ which indicates that the study of English weights and measures, instead of requiring a year or more, never exceeds 3½ weeks.

Finally, while admitting the value of the use of a universally intelligible system of weights and measures in technical literature, English advocates contend that there is no reason why the English system should not be used for this purpose and that, in any event, the metric system is not widely used in such literature in the United States. A change, furthermore, would involve translating and revising the enormous amount of technical literature already existing in the English language and the preparation of additional technical literature covering both systems for the transition period. This would be extremely costly and troublesome, they continue, and would present no counterbalancing advantages.²

IS THE METRIC SYSTEM OF SUPERIOR VALUE AND IN PRE- PONDERANT USE IN SCIENTIFIC PURSUITS?

Metric

Metric proponents assert that the metric system has demonstrated its value in pure and laboratory science and that it is in almost exclusive use in such work throughout the world, including the outstanding countries using the English system.³ In this connection they point to such facts as those set forth in Part II.⁴

They assert, furthermore, that the advantages of the metric system in scientific work are attested to by the increasing use and approval of the system in closely allied fields of activity such as industries engaged in the manufacture of watches, astronomical, optical and other instruments of minute measurement.⁵ They also cite the action of the National Institute of Inventors of the United States,⁶ an organization of several thousand members, which has passed a resolution unanimously favoring metric standardization.

English

Advocates of the English system admit that the metric system has certain advantages and an extensive use in laboratory science, but they deny that it is exclusively used in fine instrument making

¹ Halsey, F. A., and Dale, S. "The Metric Fallacy," pp. 93-95.

² United States. 58th Congress Hearings before House Committee on Coinage, Weights and Measures etc., p. 199; see also p. 171 of present report.

³ Grip, "America's Demand for a Fair Measure Deal," in which reference is made to the experience of Wiley & Co., October, 1920, p. 12.

⁴ See pp. 55-57.

⁵ Cf. American Society of Mechanical Engineers, Report No. 972, Section 10, p. 638; also pp. 58-60, present report.

⁶ New York City.

and insist, in fact, that the use of thousandths and ten-thousandths of an inch make the English system as well or better adapted to such manufacture as any system which has ever been devised. They point out, furthermore, that it is the so-called "absolute" or centimeter-gram-second (C. G. S.) system rather than the metric system which is actually employed in scientific work. The following statement is cited in this connection:

In many discussions on the merits of the metric system it is argued that scientific measurements are all stated in metric units, and that scientific men and engineers at least should be in favor of the adoption of the metric system; but this is only an approximate truth. Scientific results are stated in the C. G. S. system, and apart from the fact that the centimeter is 1/100th part of the standard unit of length and that the gramme is 1/1000th part of the unit of mass in the metric system, there is a fundamental difference in the method of measuring force or pressure, viz., that in the metric system this is expressed as the weight of a kilogram, that is to say, the force with which one kilogram (the standard mass) is attracted by the earth when at the earth's surface at Paris, whereas the unit of force in the C. G. S. system is the dyne, which is the force which acting on a mass of 1 gramme for one second gives it a velocity of one centimeter per second. The consequence is that all units in the C. G. S. system, other than units depending on length and volume, have involved in them a multiplier which prevents their being directly translatable into metric units, and hence in any case scientific measurements and calculations must be stated and carried out in absolute units, and it is no more difficult to translate to the British pound system with a table of constants at one's side, than to translate to the metric system by using a similar table. The only advantage that lies with the use of the metric system is that standard metric measuring apparatus and standard weights may be used in work being carried out in the C. G. S. system.¹

That the system actually used in scientific work is in this and other respects a mixed one demonstrates the important fact, English proponents say, that scientific workers are free to adopt, without involving consequences to other fields of activity, any units they deem most convenient for their use. In this regard, it is pointed out, science stands in a unique position. Its methods are ever changing and are easily changed. Its products are discoveries, inventions, books and the like, which are not offered for sale to the public but rather to the engineer or manufacturer. It thus does not have to cater to practices involved in standardized products nor to the long-standing habits of the consuming public. Finally, the number of persons and interests involved in the field of scientific activity are small compared with those involved in other fields.² For these reasons, English advocates conclude, the usefulness of parts of the metric system in scientific work and in fine instrument making cannot be taken as an indication of the advisability of adopting it generally in the United States.

¹ Atkinson, Llewellyn B., Member of Institute of Electrical Engineers. "Pros and Cons of the Metric System," *London Journal*, February, 1918, p. 9.

² See p. 65.

IS THE METRIC SYSTEM APPLICABLE AND VERY GENERALLY USED IN ENGINEERING ACTIVITIES?

Metric

Metric advocates contend that inasmuch as the engineering professions are all based on the natural sciences and since the metric system has been found of advantage in scientific work, it must necessarily be of advantage in engineering activity and for the same reasons.

In electrical engineering, metric proponents say, the metric system is in use practically the world over and is admirably adapted to this field. The United States, they assert, has made the use of the metric system compulsory in electrical work, and electrical standards have been established by agreement among the engineers of all countries.¹

In all stages of mechanical engineering work, they say, from the draughting of plans to the execution of them, the metric system has been found of great advantage and is coming into increasing use, providing convenient and simple methods of calculation and avoiding the possibility of error in reading plans.² For instance, it is contended that there is no fixed rule in the English system with regard to figuring drawings. Some draughtsmen mark a dimension 1'10" while others mark it 22", and expensive errors have been made through reading 2'2" instead of 22" and because of other similar misreadings. Such errors, it is claimed, are practically impossible with the metric system. Metric drawings, it is explained, are generally made to one of the following scales: full size, half size, 1 to 5, 1 to 10, 1 to 20, 1 to 50, or 1 to 100. A comparison of the ease of measuring with a common English rule a distance on a drawing $3/32$ " to the foot with the ease of doing the same thing with a metric rule on a drawing 1:100 will, it is claimed, show the greater simplicity of the metric system in mechanical drawing.³ Several manufacturers of engines and engineering firms are referred to as confirming the advantages of the metric system in mechanical engineering work.⁴

In civil engineering and land measurements metric proponents contend that their system would be of particular advantage in obviating the complicated system of rods and chains now in use

¹ See p. 61 of present report; cf. also United States. Hearings before House Committee on Coinage, Weights and Measures, Feb. 6, 1902, p. 2, ff.

² American Society of Mechanical Engineers. Report No. 972, Sections 6, 9, 13 and 19, pp. 632-646.

³ Schuhmann, George, General Manager of the Reading Iron Co., discussion of H. R. Towne's paper, "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, Sections 17 and 18, p. 913.

⁴ American Society of Mechanical Engineers. Report No. 972, Section 19, pp. 644 and 646. See also pp. 190-191 of present report.

and permitting, also, greater convenience in handling reduction scales.¹ The use of the metric system by the United States Coast and Geodetic Survey in its triangulation work is cited by the prometrics as showing its adaptability to that field, and advantages are also claimed for it in lessening liability to error in map drawing generally.

English

Defenders of the English system deny the wide use and advantages claimed for the metric system in the various fields of engineering and assert that in addition to the important fact that the English system is more widely used in engineering practice than the metric, it is, as in scientific work, a mixture of other units that is used and has been found of advantage in some connections rather than the metric system exclusively.

This is demonstrated in electrical engineering, English proponents say, where a "mongrel system," comprising the C. G. S. or absolute system, the metric system with the centimeter instead of the millimeter as a unit, and English feet, inches, and square inches, is used. The units of electrical measurement, the ohm, ampere, volt and others, they point out, are not intrinsically more metric than English. The lack of uniformity in the use of the metric system in this field, they continue, is indicated further by the preponderant use of English units in the making of electrical machinery and insulated wire and other electrical products.²

This also illustrates the fact, it is pointed out, that in the engineering profession generally, to a greater extent than in pure science, the interests of the scientist and the calculator must be weighed against the interests of the manufacturer, whom the problem of weights and measures affects quite differently. Thus the engineer, because of the increasingly close connection between his work and modern industry, must give preference to practical considerations over theoretical ones, and for this reason he tends to hold to the use of the common units of business and industry.

In mechanical engineering the most important consideration is the fact that the mechanical standards in use in this country and to a large extent throughout the world are based on the English system. For this reason, English proponents say, the metric system is very little used among the mechanical engineers in Great Britain and the United States and it has not demonstrated any superior advantages in this field. Opinion in mechanical engineering circles is unfavorable to its use, they continue, as is

¹ *Idem.*, Section 8, p. 636.

² United States. Hearings before House Committee on Coinage, etc., February, 1902, pp. 125; also, Hearings, 58th Congress, pp. 150, 151, 185, 186.

indicated by actions of the American Society of Mechanical Engineers and other like bodies.¹ In mechanical draughting, in particular, it is maintained that few drawings are made to the metric scale and that the inch is better adapted than any unit of the metric system for this purpose. The inch can be used up to more than 100 inches, down to any fraction, binary or decimal, and symbols such as feet and yards are neither needed nor used in modern practice. On the other hand, because of its small size, the use of the millimeter as a unit tends to increase the number of figures required in designating dimensions.²

As concerns civil engineering and land measurements, it is held that the foot forms a more satisfactory substitute for rods, chains, etc., than the meter; that it can be decimalized as easily as any metric unit, and that with the additional use of binary and tertiary division a convenient series of reduction scales is made use of.³

The importance of the use of familiar, old units in land measurement is indicated, English proponents continue, by the fact that where the metric system has been introduced by law, as well as in proposed metric legislation in this country, land measurements have usually been exempted because of the enormous difficulties which would be encountered in attempting to change the records of land transactions and surveys.⁴ The metric system, English proponents maintain, is thus very little used in civil engineering work even in countries where it is otherwise in general or compulsory use.

In short, English proponents contend, in all fields of engineering the English units hold a well-established place from which the metric system has not succeeded in ousting them by reason of any alleged advantages or for any other reason.

DO THE ADVANTAGES AND USE OF THE METRIC SYSTEM IN
AGRICULTURE, MINING AND TRANSPORTATION WAR-
RANT A CHANGE TO THE METRIC SYSTEM
IN THE UNITED STATES?

Metric

Metric proponents assert that the intrinsic merits and the advantages and use of the metric system in scientific fields indicate that it would be of advantage in agricultural, mining and transportation activities. The increasingly close relation, it is urged, between agriculture and scientific research in soil chemistry and the preservation and handling of food products, between mining

¹ Cf. p. 63.

² American Society of Mechanical Engineers. Report No. 972, Section 9, pp. 637-39.

³ *Idem.*, Section 8, p. 637.

⁴ Cf. p. 63.

and metallurgy and chemical engineering, and between transportation and engineering science, emphasizes the importance of having a uniform scientific system of weights and measures in all these fields. The diversity of measures used in agriculture, mining and transportation the world over, and to some extent in agriculture in the United States, in view of the growing interdependence of nations as regards food supply, natural resources and transportation, makes a uniform system a paramount desideratum. In this connection, a former Assistant Secretary of Agriculture is quoted as saying that the use of the metric system in this field would make possible an international system of crop reporting and greatly benefit the farmer.¹ Since there is no reason inherent in the nature of these fields why one system of weights and measures should be used rather than another, metric proponents conclude that the system they consider superior should be adopted.

English

English advocates answer such contentions by observing that in the United States the English system is thoroughly established and in daily use in agriculture, mining, and transportation, that it has been found adequate in filling the needs of these fields and that no demonstrable advantages would be derived from a change.² In all these fields, they point out, a change in weights and measures would affect the daily habits of the people concerned. Although weights and measures are not bound up permanently with the products of these fields, they have developed certain practices with regard to weighing and measuring which have been evolved by natural needs and found adequate. To change this current practice would involve enormous difficulties, since the number of persons concerned makes these fields of far greater importance as regards a change in systems than the fields of scientific work.³

It must be remembered also, English proponents point out, that English weights and measures are involved in the implements of extraction, cultivation and capacity measuring in agriculture and mining. Weights and measures are employed in transportation equipment and in the engineering work of building new lines. All implements and instruments embodying weights and measures now used in these connections would, therefore, be affected seriously by the change.⁴

¹ United States. 58th Congress Hearings before House Committee on Coinage, etc., 58th Congress, pp. 277-79; cf. also p. 69 of present report.

² Cf. Part II, pp. 76-77; see also, letter from B. A. Worthington, President of the Cincinnati, Indianapolis & Western Railroad Company to the American Institute of Weights and Measures, October, 1920.

³ See p. 66.

⁴ See p. 76.

In agriculture, furthermore, the experience of other countries has shown that people cling persistently to the old familiar units and that in consequence in many countries it has been necessary to exempt this field from compulsory metric laws.¹ In mining, the system used is usually the customary one of the country in question, and while the change might not be difficult except as regards its effect on the habits of the miners, there would be no point in making it in this field either.

The fact that the metric system is used in some countries in land transportation is of no significance, English proponents say, since practices in this field follow naturally the common custom or the government requirements of the country in question, and are in themselves neither better nor worse in one country than in another. Though transportation itself has no intrinsic connection with any system of weights and measures, a change to the metric system would mean that the entire traveling public would have to readjust its habits in purchasing tickets and consigning goods and be put to great inconvenience to no purpose. With regard to water transportation, moreover, the English nautical mile is in universal use and it has been found impossible to displace it because of its acknowledged superior advantages.² The laws of practically all metric countries consequently provide for the use of the English nautical mile. The English ship ton in measuring tonnage, it is pointed out, is also practically universal, and the use of these two English units is closely associated with the predominance of the English-speaking countries in shipping.

With regard to all of these fields, English proponents conclude, the importance of established habits and of the extensive use of the English system are the chief considerations against a change, especially since the metric system cannot be shown to have any special advantages over the English system in the activities in question.

DO THE ADVANTAGES AND USE OF THE METRIC SYSTEM IN MANUFACTURING WARRANT A CHANGE?

Metric

Pro-metrics maintain that the metric system is well adapted to all fields of manufacture and is in increasing and successful use in them. Its intrinsic merits and advantages in science and in the manufacture of delicate instruments for minute measurement, and the increasingly close connection between science and engineering and modern mechanical industry make it obvious, they say, that the metric system is being more and more considered of advantage to industry generally. Lists of manufacturers in the United States who use the metric system extensively in their plants and

¹ See p. 68.

² See pp. 72-73.

others who have adopted it for special uses, such as in the manufacture of products for export to metric countries, are presented by metric advocates to show the adaptability of metric units to this field.¹ The experience of The De Laval Separator Company is cited as an example of the successful use and adaptability of the metric system to manufacturing processes.² The testimony of the Goodyear Tire & Rubber Company is also quoted in this connection to the effect that the company gave serious consideration to the advantages and disadvantages of adopting the metric system in its plants and concluded that the advantages were considerable while the disadvantages were not serious and that the exclusive use of the metric system would result in a great saving in time and a reduction of errors, as well as provide a universal system for all plants in this industry throughout the world.³ Not only are the industries of the leading metric countries firmly established in its use, but many modern British firms, such as certain manufacturers of motor cars, aircraft, electrical apparatus, etc., already employ the metric system. The growth of international industrial dependence, which is bringing about a world-wide interchange of manufacturing processes and products, they say, is revealing more clearly every day the drift toward a uniform system and the advantages of the metric system in the industrial field.

English

English proponents assert, however, that the metric system offers no advantages and has achieved very little use in manufacturing in general. Replies to questionnaires similar to those described in Part II, Chapter VIII, and in addition testimony of individual manufacturers⁴ indicate that the English system is considered much more applicable than the metric to manufacturing processes, and there is no indication, English proponents insist, that sentiment to the contrary is developing.

Even the much quoted Goodyear Tire & Rubber Company, they point out, is not in favor of the compulsory adoption of the metric system "because of the enormous expense and confusion that would result to manufacturers," to quote the words of one of its executives.⁵ There are, furthermore, English proponents say, reasons of the highest importance why a change to the metric system would be greatly disadvantageous to the indus-

¹ Stratton, Samuel W., Director of the Bureau of Standards. "Metric System in Export Trade," Report to the International High Commission, Senate Document, No. 241, 64th Congress, 1st Session, January 6, 1916, p. 7.

² World Trade Club. Pamphlet, "What Will Metric Standardization Cost?" San Francisco, Cal., p. 16.

³ *The Decimal Educator*, September, 1920.

⁴ Cf. Results of the Board's questionnaire; also Mr. J. Sellers Bancroft, William Sellers & Co., Towne, Henry R., "Our Present Weights and Measures and the Metric System," *Proceedings of the American Society of Mechanical Engineers*, 1906, p. 361.

⁵ Letter to N. I. C. B. from M. L. Kochheiser, Sales Promotion Dept., The Goodyear Tire & Rubber Co., Akron, Ohio, September 9, 1921.

tries of the United States. A very different situation, they point out, exists in the manufacturing field from that in the fields of science, engineering, agriculture, mining and transportation, with the products of which weights and measures are not permanently bound up. Manufacturing is a field in which things are made to measure and the measures used are joined with the resultant product in varying degrees of intimacy.¹ In the making of a commodity to measure the important consideration is that the product be made of convenient size or handy weight and that the measure or weight adopted be perpetuated in order that the business built up about the particular product may continue and be successful. The making of things to measure on a huge scale, i. e., the production of articles in standard sizes and forms in large quantities, is the essence of modern industry, English proponents assert, and to her leadership in this field the United States owes her prosperity and power. The manufacturing field, they continue, is one of the most important fields of economic activity in the United States. It has been built up in and around English units, the destruction of which would create chaos in American industry.

Certain industries in particular have developed in the English system not only in the United States but throughout the world. In the textile industries English yarn counts are used in practically every country, especially in the cotton industry, 74% of the world's textile trade being carried on in the English system.² The importance of the textile industry in the United States and its dependency upon English units, are illustrated in the following quotation:

Measured by the number of wage earners, capital employed or wages paid, textile manufacturing is the leading industry of the United States. One of the most valuable possessions of this great industry is the system of textile standards based on a few convenient English units of weight and measure. It is a remarkable fact that practically all of the measurements that are necessary in the many complicated processes of manufacturing textiles are made with six units, two of length and four of weight—the yard, inch, pound, ounce, dram and grain. This simplicity of standards which are as familiar as our mother tongue, greatly facilitates calculations and understanding at every step in the manufacture and marketing of textile products.³

In metal products also, English machine standards based on the English system predominate even in metric countries.⁴ In the manufacturing of food products, English proponents point out

¹ See p. 98.

² Cf. Part II, Chapter 8, pp. 80-83. Cf. also American Society of Mechanical Engineers, Report No. 972, Appendix VIII, pp. 690-91; see also Evidence before Committee on Commercial and Industrial Policy in 1917 Relative to Arguments For and Against the Adoption of the Metric System in the British Empire.

³ Reprint from *Textiles*, October, 1919. "The World Trade Club of San Francisco and Its Metric Propaganda."

⁴ Cf. Part II, Chapter 8, pp. 83-85; Cf. also American Society of Mechanical Engineers, Report No. 972, Section V, pp. 668 and 670.

that a large amount of these products manufactured in the United States and Great Britain are found in foreign markets and that English weights and measures have accompanied such sales. The labeling of these products in metric equivalents where called for fulfils, they say, all trade needs in this manufacturing field.¹ The preponderance of the English system in the rubber industry,² of which product the United States, Canada and England consume 87.25% of the world's production, is pointed to. In lumber the inch and foot prevail almost universally in the cutting of boards.³ In printing, type sizes have been standardized in the United States, France and elsewhere on the basis of the inch.

English proponents sum up the extensive use of the English system in manufacturing as follows: Seventy per cent of the world output of steel is manufactured in the United States and Great Britain on the inch and pound basis, the metric system being hopelessly outdistanced in this field; approximately two-thirds of the world production of machine tools is made to the inch; according to estimates of the National Screw Thread Commission appointed by Congress to study the question of screw thread standardization and which met in London and Paris in 1919, 80% of the world production of screw threads is made to the inch; in 1919, the United States and Canada consumed for manufacture about 75% of the world production of crude rubber; according to the estimates of the United States Automobile Chamber of Commerce, the United States manufactures 90% of the world production of motor vehicles; the standard unit by which lumber is measured the world over is the board-foot, a board one foot square by one inch thick; 95% of the world's cotton spindles are spinning to the yard and pound while only 5% are spinning to the metric measurements and weights; the *denier aune* is the world's standard for raw silk and all efforts to substitute the metric standard have failed even in metric countries; and approximately two-thirds of the commerce of the world in manufactured products is on the basis of the English-American system of weights and measures.⁴

¹ Cf. Part II, p. 87.

² *The India Rubber World*, "The London View of the 1919 Crude Rubber Market," New York, March, 1920; American Institute of Weights and Measures, Leaflet, "The Rubber Industry and the Metric System," a statement of the value of United States tire exports, reprinted from the February issue of *The English Speaking World*, New York; Cf. also Part II, Chapter 8, pp. 95-97; *The India Rubber World*, May 1, 1920.

³ Cf. Part II, Chapter 8, pp. 88-90; American Institute of Weights and Measures, Leaflet, "The Lumber Industry and the Metric System"; Letter from V. L. Havens, Editor of *Ingenieria Internacional*, New York City, to the American Institute of Weights and Measures regarding the use of the English system in the lumber industry of South America, August 23, 1920.

⁴ American Institute of Weights and Measures Pamphlet, "Shall the Tail Wag the Dog?"; Report of the British Board of Trade, 1919; *Machinery*, "Inches Versus Millimeters," opinions by some of the leaders in the American Tool Industry, April and May, 1920; Findings of the National Screw Thread Commission, Appointed by Congress in 1919 to study the question of screw standardization; *India Rubber World*, "The London View of the 1919 Crude Rubber Market," N. Y., March, 1920; Automobile Chamber of Commerce, estimate of the United States manufactures of motor vehicles; Letter from V. L. Havens, editor of *Ingenieria Internacional*, New York City, to the American Institute of Weights

In short, it is contended, English units are so bound up with manufacturing processes, especially in the United States, that their destruction would be disastrous to American industry and would leave the United States in a very unfortunate position industrially while metric countries secured the advantage. The characteristics of modern manufacturing industries, the leadership of the United States in them, and the testimony of manufacturers themselves, English proponents assert, indicate conclusively the necessity of maintaining the English system in this field.

WOULD A CHANGE TO THE METRIC SYSTEM BE ADVANTAGEOUS IN DOMESTIC TRADE?

Metric

Metric proponents argue generally that metric units have certain advantages for use in domestic trade because of their simplicity and other characteristics previously discussed. They assert, further, that the multiplicity, variation and confusion which they allege exist in English weights and measures in the field of trade make the advantages of the metric system daily more obvious. They stress the increasingly close connection between the industrial process, by which the products handled in the trade are manufactured, and the work of engineering and the laboratory scientist, concluding that a uniformity of weights and measures all along the line, from the experimental research stage to the consumer, would afford great advantages in modern industry and business.¹

English

Advocates of the English system deny the assertion that the metric system has inherent merits over the English as applied to the field of trade and point to the handy convenience for daily use of English units already discussed.² As for an alleged variation and confusion among English units, nothing could be farther from the truth, English proponents assert. The variation complained of, they contend, lies in the merchandise, which varies in weight per given volume according to the specific gravity of the commodity, and has nothing to do with the particular system of weights and measures used.³ It is also asserted that the purported relation between trade and science should be an argument in favor of utilizing the English system more extensively in science rather than the other way around, since the field of domestic trade in the United States is so much larger and Measures regarding the use of the English system in the lumber industry of Latin America, August 23, 1920; American Institute of Weights and Measures, Pamphlet, "Why World Trade Facts do not support the Metric System"; *Automotive Industry*, "The English Speaking World," February, 1920.

¹ Cf. pp. 204-5.

² Cf. pp. 139-140.

³ Cf. p. 209.

and more vitally concerned in the question of a change in weights and measures than science is.

The chief requirement regarding weights and measures used in trade, English proponents repeat, is that they be convenient and familiar to the public. The hundreds of thousands of dealers as well as the whole buying public in the United States, who are at present using the English system, are familiar with it and find it perfectly satisfactory. No advantage would be gained by the adoption of the metric units in this field and needless confusion would result from forcing it upon the people, as the experience of metric countries shows. This experience indicates, it is contended, that in all probability the field of retail trade in the United States, by far the largest of the domestic trade groups, would in the event of a change be one of the last to adapt itself to the metric units, inasmuch as the public for a long time clings to old units in spite of metric laws; and since metric units are as a matter of fact inferior for purposes of trade to English units, it is claimed that there is no warrant whatsoever in making a change in this field.

WOULD A CHANGE TO THE METRIC SYSTEM BE ADVANTAGEOUS TO THE FOREIGN TRADE OF THE UNITED STATES?

Metric

Advocates of the metric system base their argument for its use in foreign trade activities on the relation of the United States to the trade of metric and other countries rather than upon any intrinsic merits of the metric system in foreign trade.

They contend, in the first place, that their system is used more extensively in foreign trade than the English system. They say¹ that, in addition to its wide trade use by metric countries, an overwhelming proportion of the foreign trade of Russia is based on the metric system, that Great Britain for practical purposes has adopted the metric system in manufacture for foreign trade and that since the war the system has extended into other fields of commerce there. A similar development, they hold, is taking place in the United States. It is also maintained that most of the countries using the metric system only nominally, such as China and Japan, are now taking it over more completely for trade purposes. China, it is claimed, is a large user of the metric system in foreign trade and is now formulating a plan to make it the only system recognized, while Japan has recently gone even farther.²

¹ Wells, William C., Chief Statistician, Pan-American Union, Washington, D. C. "The Metric System from the Pan-American Standpoint," *Scientific Monthly*, March, 1917, p. 202.

² See footnote, p. 32.

Metric advocates assert that because of this extensive use in so large a proportion of the commercial nations of the world, the United States would inevitably gain trade by adopting the system. It is pointed out that the trade of the United States and Great Britain with the countries of metric Europe was of relative unimportance in 1913, which represents a more normal period than subsequent years do, the United States furnishing less than 12% of their total imports and Great Britain hardly as much as 10% of the whole.¹ Through the adoption of the metric system to facilitate trade relations, pro-metrics maintain, the share of the United States in the import trade of metric Europe would be undoubtedly made much greater. They assert further that since Germany is probably out of export trade for a considerable period, unless the United States adopts the metric system a large part of Germany's trade, especially in Latin America, will go to France, Italy, Spain and other metric countries, and that the United States will not be able to follow up the advantage in this regard gained by her during the war.² By way of general testimony on this point, the following statement from an American industrialist is presented:³

The United States is on the threshold of an enormous expansion in its foreign trade. The adoption of the metric system would strengthen our position with every foreign client—save possibly the British—and it would greatly simplify our foreign transactions. . . .

Of the world's automobiles, it is pointed out, probably 80% are made in the United States, and the same holds true of typewriters, telephone instruments, linotype machines, cash registers, calculators, slide-rules, sewing machines and the like. In order that these appliances may sell and hold the trade to best advantage the world over, it is argued, they must be made so as to conform to the customary units of the countries to which they are sent.⁴ Former Secretary of Commerce of the United States, William C. Redfield, is quoted in this connection as follows:

In my own experience as a manufacturer of engineer's tools, we were forced to recognize that unless we followed this same principle (the scientific) we might just as well not attempt to sell goods abroad, and if we did not sell any goods abroad our factories were too big. Consequently we looked to see what the world wanted, and we found that the machinery and tools that Germany, Switzerland, Italy and France sent to South America were built on the metric units. We found it absolutely necessary, if we were going

¹ Cf. Part II, Chapter 9, p. 107.

² Reprint from *Bulletin of the Pan-American Union*, "Exporting to Latin America," February, March and April, 1919, p. 27; World Trade Club, *Weekly Metergram*, "World Trade Needs Meter—Liter—Gram." Statement of William Hammer, President of the World Trade Club, in paper read before American Association for Advancement of Science in St. Louis, Mo., December 28, 1919, p. 21.

³ World Trade Club, Pamphlet, "Who Suffers?" p. 14.

⁴ World Trade Club, Pamphlet, "An Evening at the World Trade Club," and address to the members of the World Trade Club by Aubrey Drury, Associate Editor of the *Journal of Electricity*, p. 20.

to hold our own against our competitors, to follow their example. We then manufactured our wrenches with openings cut to the metric units. . . . It was before 1900 that the change was made. In that year I spent ten months selling goods in France, Belgium, Germany and Denmark; and I found that if the goods had not been made in the way the people wanted them to be made we should have had to stay out of the business altogether.¹

In the second place, not only do pro-metrics assert that the United States would gain foreign trade by the adoption of the metric system, but they say that she will lose considerable trade by clinging to English units, especially since the export of products to Latin America now requires a double marking which they claim is very undesirable to Latin-American importers.² Instances are cited in which the metric system is used by exporters in the United States in marking their products in foreign countries. A manufacturer of canned goods is quoted as stating that to meet competition he is constantly making in his cans changes greater than that which would be necessary in adopting metric-size cans. Our trade in other products such as grains, flour, chemicals, etc., with metric countries involves only a change in marking the container and not in manufacturing equipment. Flour, for example, is reported as being packed for Latin-American export trade in containers holding integral numbers of kilograms (barrels of 180, 150 and 120 kilos) and the same is true of all the cement exported to South America.³

It is also contended that arguments similar to those presented here have been advanced by pro-metrics in Great Britain, in order to influence the government to change to the metric system, which would indicate that a change in Great Britain is considered desirable and about to be undertaken for similar reasons. If such a change is likely, they say, it will make the disadvantages in foreign trade under which the United States now labors so much stronger, and it would be desirable for the United States to anticipate such a move on the part of Great Britain.

In brief, metric proponents assert that the use of the metric system in foreign trade is more extensive than the use of the English system; that this extensive use warrants the conclusion that the United States would gain trade by changing systems; that such a change would merely conform to the principle of giving foreign customers what they want, which the United States is already forced to do in manufacturing many products to metric

¹ Redfield, Hon. W. C., former United States Secretary of Commerce, in an address before the American Association for the Advancement of Science, Metric Session, at Baltimore, Md., December 27, 1918.

² World Trade Club, Leaflet, "An Evening at the World Trade Club," pp. 23 and 24.

³ Stratton, Samuel W., Director of the Bureau of Standards, "The Metric System in Export Trade," January 6, 1916, Senate Document No. 241, 64th Congress, 1st Session, pp. 7, 8 and 10.

dimensions; and that the United States would not only gain trade by a change but will lose considerable trade otherwise, since the world is more and more coming to use the metric system in trade practices.

English

In the first place, English proponents deny claims that the metric system is in predominant use in foreign trade, in substantiation of which denial they point to the data concerning extent of use of that system in the export trade of various countries as discussed in Part II, where it is indicated that the trade of the United States, Great Britain and other countries using the English system substantially exceeds that of countries using the metric system and that the market for products in the English system extends to all parts of the globe.¹

Regarding the trade of such countries as China and Japan, it is pointed out that in 1918 the United States and Great Britain with Japan held over four-fifths of China's trade while metric countries carried on but a relatively small amount, in the light of which facts the statement that China is a large user of the metric system in foreign trade has no foundation. A similar situation, it is claimed, obtains with respect to Japan and other countries using a mixture of systems.²

With respect to the claim that where goods are sent from English countries to metric countries metric units are used to a great extent, English proponents insist that there is comparatively little demand for the handling of products in the metric system.³ Testimony is presented to show that the United States foreign trade correspondence includes only rarely a reference to metric units, hardly more than an occasional listing of prices, and that comparatively few American firms resort to double markings.⁴ This is particularly illustrated in the trade of the United States with metric Latin America, in which trade she has made great strides in recent years and now holds a leading place.⁵ The English system, it is asserted, has been found acceptable to the great majority of Latin-American importers⁶ and the imports

¹ Cf. Part II, Chapter 9, "Foreign Trade," Table III, p. 103, and Chart "World Export Trade," p. 105. Cf. also "Evidence Before Committee on Commercial and Industrial Policy in 1917 Relative to Arguments For and Against the Adoption of the Metric System in the British Empire"; also American Institute of Weights and Measures, Pamphlet, "Why World Trade Facts Do Not Support the Metric System," New York.

² See p. 108.

³ Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, Section 65, p. 864.

⁴ Tentative Report of the Committee on Weights and Measures of the American Society of Mechanical Engineers, "The Metric System in Export Trade," June 4, 1918.

⁵ Cf. Part II, pp. 106-107.

⁶ Tentative Report of the Committee on Weights and Measures of the American Society of Mechanical Engineers; see also "The Weights and Measures of Latin America," by F. A. Halsey, Dec., 1918; Cf. Part II, Chapter 9, p. 104; and Results of Board's Questionnaire, p. 113.

into these countries consist in preponderant degree of manufactured products in which the English system of weights and measures is definitely incorporated.¹

The following statement sums up the position of English proponents in this respect:

Of the millions of dollars worth of machine tools which the members of the Association have sold to France and Germany, the great majority have been sold without request or suggestion that any of the dimensions be made in accordance with the metric system. The only changes that have been asked for have been in occasional measuring and adjusting screws. In view of this experience and of the unexampled growth of the export trade of this country during the past half-dozen years we cannot see any need of changing for the benefit of foreign trade.²

In the second place, it is pointed out, since more than half of the trade of the United States is with non-metric countries, most of which use the English system as the standard, and since the United States and Great Britain already control the world's trade in many products in which the English system is incorporated, such trade would suffer incalculably by a change to the metric system in this country, and unless Great Britain made the change simultaneously with the United States the result would only redound to Great Britain's advantage. Such a loss in favor of both Great Britain and metric countries, it is urged, would be immeasurably greater than any possible gains the United States might secure.³ With respect to the observation made by promoters that the world's output of machinery, automobiles, textiles, lumber, rubber goods, iron and steel products is practically controlled by the United States and Great Britain, it is contended that the significant fact to remember is that these products are for the most part manufactured in English units and are being accepted without change even by metric countries. In view of the fact, therefore, that the nearest approach to world uniformity in trade has been achieved by non-metric England and America, these countries would, through a change, not improve their trade position, but on the contrary would surrender to Germany or other metric countries the advantages they now

¹ Cf. Part II, pp. 109-110, and Appendix Table 6; also Tentative Report of the Committee on Weights and Measures of the American Society of Mechanical Engineers, "The Metric System in Export Trade"; Halsey, F. A., "The Weights and Measures of Latin America."

² American Society of Mechanical Engineers, Report No. 972, p. 698; Cf. also *India Rubber World*, "The Metric System Applied to the Rubber Industry," May 1, 1920; Jandron, F. L., Packard Motor Car Co., Letter to World Trade Club, 1919; American Institute of Weights and Measures, Leaflet, "Why World Trade Facts Do Not Support the Metric System"; American Institute of Weights and Measures, Leaflet, "Our System of Weights and Measures No Bar to World Trade"; Towne, H. R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, Section 63, p. 864.

³ American Institute of Weights and Measures, Leaflet, "Why World Trade Facts Do Not Support the Metric System," New York; Final Report of British Committee on Commercial and Industrial Policy After the War, July, 1918, Chapter 10, p. 55; "Evidence Before Committee on Commercial and Industrial Policy in 1917 Relative to Arguments For and Against the Adoption of the Metric System in the British Empire."

enjoy and create a confusion and loss vastly greater than any possible benefits that might accrue.

In brief, English proponents point out that the use of the English system in foreign trade is considerably more extensive than the use of the metric system; that there is little demand even in metric countries for imported goods from the United States made to metric measurements; that the use of English units in export trade is steadily increasing and developing more rapidly than the use of metric units in such trade; and that since the United States and Great Britain already control the world trade in products in which English units are intimately incorporated, and since the nearest approach to world uniformity in trade has been achieved by non-metric United States and Great Britain, no possible advantages could result from a change to the metric system, but on the contrary, through such a change Great Britain and the United States would lose the vast trade they now possess with non-metric countries and with respect to metric trade they would surrender their advantages to such metric countries as France and Germany. English proponents contend, in other words, that the metric system has neither intrinsic advantages nor a sufficiently extensive use in foreign trade to warrant the assumption that its adoption would benefit the export trade of the United States.

CHAPTER XIII

PRACTICABILITY OF MAKING A CHANGE TO THE METRIC SYSTEM IN THE UNITED STATES

The arguments considered in the preceding chapters bear on the *desirability of adopting* the metric system in this country in view of its intrinsic merits and its advantages and use in special fields. After this question has been decided, however, there still remains the quite independent question as to the *practicability of making a change* from the English to the metric system.

The discussion by English and metric proponents, of the practicability of a compulsory change, concerns the varying views of both parties, not only as to the difficulties involved in the light of the experience of other countries and of the situation here, no matter how the change were brought about, but also as to the effect of various forms of compulsory law aimed to bring about the change. The manner in which it is understood that the compulsory change would be brought about, and the form of compulsory law that should be applied, greatly affects the arguments relative to the practicability of a change.

The question of practicability therefore involves three main issues; first, does the experience of other countries indicate that there would be serious general difficulties involved in a change in the United States through its relation to general popular customs and habits and to practices in the chief fields of activity, and how would various forms of compulsory law affect these difficulties; second, how and to what extent would such a change affect established mechanical standards; and third, would the cost of a change in this country be prohibitive?

DOES THE EXPERIENCE OF OTHER COUNTRIES INDICATE THAT THERE WOULD BE SERIOUS GENERAL DIFFICUL- TIES INVOLVED IN MAKING SUCH A CHANGE IN THE UNITED STATES AND WHAT IS THE RELATION OF COMPULSORY LAW TO SUCH DIFFICULTIES?

Metric.

Proponents of the metric system declare that, in general, the experience of other countries demonstrates that the difficulties in-

volved in such a change are greatly exaggerated by supporters of the English system and that the people of the United States would adopt the new units without serious confusion after a relatively short transition period, especially if the legislation requiring the use of the metric system were limited at first to certain activities and gradually broadened in scope.

The metric system, they say, has easily and quickly supplanted older units of weight and measure for all practical purposes in other countries that have made the change, and although they acknowledge that older units are occasionally still used in some fields and in isolated districts, they contend that, generally speaking, such units have passed out of existence. They insist that the experience of European metric countries,¹ and of Latin-American countries² in this regard bears out their claim that the change would be quickly and easily accomplished in the United States.

It is stated that in Germany the change was made with little confusion, in the cities in the course of a few weeks, in the country in a few months, and in a year the metric system was practically in general use.³ Old carpenters and other mechanics who had used a foot rule all their lives were naturally somewhat slow to use the new system, but it is contended that most workmen took to the metric system very quickly.⁴ In Austria⁵ there was some confusion in changing from old measures to those of the metric system during the first two or three years, but it is held that after this period no trouble was experienced. As indicating the rapidity of the change in Switzerland, it is stated that the government, in passing the compulsory metric law, exempted the watchmakers from the operation of the law but that the latter soon realized the disadvantage under which they were working in using the old units, and in a comparatively short period voluntarily adopted the meter-liter-gram exclusively.⁶ As regards the effectiveness of the change in Latin America, the metric contention is expressed in the following quotation:

All the Latin-American countries use the metric system of measures in domestic trade and production. It is the only system

¹ United States. Bureau of Foreign and Domestic Commerce. *Commerce Reports*, Washington, D. C., 1920 and 1921; Guillaume, Ch. E. Bureau of International Weights and Measures, "Le Recent Progrès du Systeme Métrique," Sevres, France; Publications of the United States Bureau of Standards, American Metric Association, New York, and the World Trade Club of San Francisco.

² *Bulletin of the Pan-American Union*, "The Metric Standard," January, 1917, p. 27. Publications of the World Trade Club of San Francisco, The American Metric Association, New York, and United States Bureau of Standards.

³ World Trade Club, Pamphlet, "Keep the World War Won," p. 11.

⁴ Schuhmann, George, General Manager of the Reading Iron Co., discussion of paper by Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings American Society of Mechanical Engineers," 1906, p. 912.

⁵ Smith, J. H., discussion of paper by Towne, Henry R., "Our Present Weights and Measures of the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, p. 916.

⁶ World Trade Club. Pamphlet, "An Evening with the World Trade Club," p. 18.

known to the great majority of the people. It is taught exclusively in the schools and is the basis of all government and commercial reports. Fiscal systems are founded thereon, land and property taxation and all commercial transactions dealing with land or the produce thereof conform to the metric system of measure. No one can do business with Latin America without understanding the system. Foreign trade is based entirely on metric measures. Old Spanish and Portuguese measures are practically extinct even in domestic transactions, and in foreign trade entirely so. Among the less educated people in certain localities the names of some of the old measures still survive, but it is the name and not the measure itself that survives, the measure itself having been changed to conform to the metric scale.¹

As is indicated in the last sentence of the preceding quotation, metric proponents claim that the assertions of English advocates "that many old units still exist" are based upon a confusion of ideas; that the old names, where retained, have taken on a new content in accordance with the metric system, as for example, the Spanish *libra* which is still sometimes used but has, they say, become equivalent to $\frac{1}{2}$ kilogram.² Mr. William C. Wells of the Pan-American Union, quotes his experience in this respect as follows:

Scarcely a vestige of the old standard is left in any country that has adopted the metric system. Now and then in Latin-American countries one will hear the old words, but almost always with a meaning adapted to the new scale. Sometimes apparently the old measure is kept. Thus, in Chile in the nitrate industry apparently they keep the old Spanish quintal, 100 Spanish pounds, a little over 101 pounds avoirdupois. This seemed curious to me, the more so since all Chilean statistical reports give weights of nitrates in the metric scale. When I was last in Northern Chile I inquired into this and found that there was not a weighing machine in all the nitrate fields graduated to the old Spanish scale. They used the metric scale, but they measured 46 kilograms to the quintal, and 46 kilograms is not exactly the old quintal.³

Metric advocates assert also that in countries where the metric system has been adopted, difficulty in making the change has been evidenced only among ignorant people and that the retention of ancient units in these countries and among such classes does not constitute an argument against a change. The mere fact, they say, that the use of ancient terms continues in certain isolated industries and communities carries no more weight than does the fact that we still retain Roman numerals on our watch faces or that the Gregorian calendar has not yet entirely displaced the Julian calendar or that older units remained in use for a genera-

¹ Wells, William C., Chief Statistician of Pan-American Union, "The Metric Standard," *Bulletin of the Pan-American Union*, January, 1917, p. 27.

² *Idem.*, pp. 26 and 27.

³ *Idem.*, p. 27.

tion after the adoption of our decimal currency in the United States.¹

In view of the simplicity and ease of use of the metric system as previously set forth, they maintain, it is unlikely that any class of the educated population in the United States would find the system difficult to acquire in a short time. Rather would the uniformity and standardization which the metric system of measures would bring, they continue, make the people of the country welcome such a change and adapt themselves to it quickly. There is thus no foundation, they assert, for the view that it would take at least two generations for the English speaking peoples to learn to think in the metric system.²

The aids and facilities for using the metric system, it is argued, are available as never before. French and German metric literature is quite complete and in the event of a change in the United States it would be necessary merely to reprint this material.³ In fact, metric sizes of material, metric gauges and metric measuring instruments of all kinds as indicated by catalogs, etc., are already increasingly common in this country. Metric data are found everywhere. The Bureau of Standards, it is pointed out, has issued publications descriptive of the metric system, containing definitions, tables of equivalents and graphic charts. Through the use of such literature, which is easy enough to prepare, it is held that many technical difficulties in the change as regards its relation to various fields and to the public generally would be overcome.

Finally, metric proponents contend, the manner in which the change is brought about could be adjusted so that it would take place in easy stages and cause little confusion or inconvenience to any of the various interests of the country. By first requiring its use in government departments and in the schools, they say manufacturers and the public generally could gradually familiarize themselves with it and adapt themselves to it. Following this, its use might be extended by legislation to domestic trade. In this way the manufacturing field would be given ample time and inducement to adopt the system voluntarily. The Government under such legislation, it is held, would make no requirements upon manufacturers that they could not fill with present equipment. All that would be necessary is that dimensions and weights be described in metric terms in the drawings, contracts and transactions with the Government, there being no intention to compel the use of the metric system in manufacturing processes themselves. Manufacturers, under any rational metric legislation, it is claimed, would be left free to work in any system they

¹ American Society of Mechanical Engineers, Report No. 972, p. 656; see also pp. 448 to 491 of Discussion accompanying Report No. 972.

² *Idem.*, p. 667.

³ *Idem.*, Section 20, p. 650.

desire, although the superior advantages of the metric system, as well as its required use in trade, would soon lead manufacturers to apply it in their plants.

English

English proponents maintain on the contrary that the experience of other countries and a consideration of the situation in the United States show that the change to the metric system would involve enormous disturbance to the every-day habits and customs of the whole buying and traveling population of the country and would create untold confusion in business practices which would require a long transition period to overcome, no matter how compulsory legislation were applied.

In the first place, the assertion of pro-metrics that a change in other countries has been easily and quickly made is flatly denied. To show the general difficulties involved in a change as indicated by the continued and extensive use of the old units in metric countries, statements from United States Consuls stationed in these countries, and from individual engineers, commerce officials, and others who have made a study of the use of weights and measures in such countries are cited.¹

The following testimony pertaining to Latin-American countries is considered by English proponents typical and representative of all Latin America:

VENEZUELA

In spite of the stringency of the laws of Venezuela, the people at large, especially in the country, still cling to old units in their every-day life and talk and think in terms of them.²

ARGENTINA

Many quotations on the market are made in tons, pounds, etc. City land is sold by the square vara. Wine, etc., from France, Spain and Portugal and out on the Argentine Andes at Mendoza is sold by the pipe and barrel. I notice advertisements in the street

¹ Leaflet of American Institute of Weights and Measures containing extracts as follows: 1. "The Metric System," *Rochester Herald*, April 8, 1920. 2. "The Sinister Metric System," *The Fire Engineer*, April, 1920. 3. Reprint from St. Louis, Mo., *Post-Dispatch*, May 9, 1920. See also American Society of Mechanical Engineers. Report No. 972, discussion by S. M. Kielland, p. 704-5; Halsey, F. A., "Weights and Measures of Latin America," December 13, 1918, pp. 11-12; Dale, Samuel S., "The World Trade Club of San Francisco and its Metric Propaganda," (Reprint from *Textiles*, October, 1919); Evidence before Committee on Commercial and Industrial Policy in 1917 Relative to Arguments For and Against the Adoption of the Metric System in the British Empire; Dale, Samuel S., "Uniformity or Confusion of Weights and Measures," *Textiles*, February, 1918; Towne, H. R., "Our Present Weights and Measures and the Metric System," "Proceedings of American Society of Mechanical Engineers," 1906, discussion pp. 879-925; Halsey, F. A., Letter to *New York Times*, March 2, 1919, III, 2:6; Report of the Cleveland Chamber of Commerce on the Metric System. A Report in Opposition to its Compulsory Adoption, June 16, 1920; Dale, Samuel S., "Pan American Weights and Measures," *Textiles*, Boston, Massachusetts, November, 1920; United States. Bureau of Foreign and Domestic Commerce, *Commerce Reports*, Washington, D. C., 1919 and 1920.

² United States Bureau of Foreign and Domestic Commerce, *Commerce Reports*, March 29, 1918, p. 1214.

cars of wine sold by the frasco. As large estancias change hands they are sold by the square legua. I notice that there is one ton of 918.8 kilos. I have run into a few others; for example, a metric ton of 1,000 kilos, . . . another of 1,004 kilos; another of 1,016 kilos, and another 1,018 kilos. Many building operations are conducted on the old Spanish measurements. . . . Machinists and others are extremely familiar with English measurements as well as Spanish and metric because they have to use all three of them.¹

GUATEMALA

I have to say that the yard measure is more in use here than the metric system. The Spanish yard is generally used. As for weights, the pound is the most generally used.²

CUBA

In reply, I have to say that upon careful inquiry and investigation, I find that while the metric system has been officially adopted in this country, as the standard of weights and measures, it is by no means in general use by the common people in trade. There are some trades, professions, and mercantile establishments, however, that have adopted and used the system to some extent, notably, physicians, druggists, and pharmacists, surveyors, carpenters and brick masons.³

A similar situation, it is maintained, is indicated by the following quotations regarding European metric countries:

TURKEY

It appears to be the object of the Government to make this the exclusive system of weights and measures, but so far, outside of official circles, the metric unit is little used. In fact, in the interior, the system is practically unknown, and it is doubtful if it will be popularly accepted for many years to come, if at all. The people find the new system very much simpler from a mathematical point of view, but its units are meaningless to them until converted into the units of the old system, for the decimal system as applied to potatoes or sugar cannot be kept constantly before the mind as can the decimal system as applied to money. It is, therefore, infinitely more difficult to learn and the attempt to introduce it has been productive of no little confusion.⁴

GERMANY

The metric system is perhaps more nearly universally used in Germany than in any country, but even there the Mailed Fist failed to completely suppress the old measures.⁵

¹ Letter to F. A. Halsey from E. F. Du Brul, of Miller, Du Brul and Peters Manufacturing Co., Buenos Aires branch.

² Letter from Alfred A. Winslow, United States Consul General, Guatemala City, presented by F. A. Halsey in discussion of paper by Towne, H. R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, Section 58, p. 892.

³ *Idem.*, letter from R. E. Holladay, United States Consul, Santiago de Cuba.

⁴ Report of United States Consul General Ravndal, Constantinople. United States. Department of Commerce. *Commerce Reports*, June 29, 1920, p. 1839.

⁵ Toledo Scale Company, Toledo, Ohio, "Metric System of Weights and Measures vs. English System," *Toledo System*, April 3, 1920, p. 4; see also *American Machinist*, May 30, 1907, p. 784.

Commenting further on the change in Germany, advocates of the English system quote Thomas E. Butterfield, Associate Professor, Mechanical Engineering, Lehigh University, as follows:

My college enthusiasm for the metric system did not survive my employment as an engineer in Germany, the chief metric country; I found that the metric system was not in universal use there after a generation of compulsory legislation.¹

English advocates refer also to the statement of Mr. Samuel S. Dale, that in Germany, after forty years, the old units still persist in the textile industry; and to the statement of Mr. Henry Hess of the German Niles Tool Works, Berlin, in 1902, to the effect that "the Rhenish inch is nearly universally used in the building trades."²

GERMANY, BELGIUM and FRANCE

While discussing with the manager and engineers of a large German concern the type, output and cost of special machines used in certain lines of the steel industry, I purposely kept the conversation, which was carried on in German, confined to English expressions of weights and measures. I found these men as well informed as I was on the system in daily use with us. . . .

The curious fact was noticed in Paris, Brussels, Cologne and in a number of smaller cities that many stores in exhibiting merchandise gave prices per pound, half pound and quarter pound, showing that it is practically impossible to abandon by law the use of long accustomed expressions and change the habits of a people.

American metal working machines and machine tools of every variety which I saw at work in Belgium, all gave excellent account of themselves and presented no difficulties to the workmen because they had been built to our English system of measurement.

In France especially, large American machine tools are badly needed for the work of rebuilding the crippled and partly destroyed industries. The French industrialists are very favorably disposed toward American machines.³

As regards France, the country in which the metric system originated, English proponents declare that while the metric system was made mandatory by compulsory law of most drastic character in 1793, the repeal of this law in 1812 caused a rapid reversion to the use of old units, and that while in 1837 a stringent compulsory law was again enacted, at the present time after a lapse of almost one hundred years, the old units are still in use.⁴ The present situation in France, it is pointed out, has been well stated in a recent letter to the president of a local chamber of com-

¹ American Institute of Weights and Measures. Leaflet, "Colleges and the Metric System."

² Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, pp. 857-8.

³ American Institute of Weights and Measures. Leaflet, "Our System of Weights and Measures No Bar to World Trade"; cf. also statement of R. Blockhouse, General Manager Belgo-American Corporation, to C. C. Stutz, Secretary American Institute of Weights and Measures, New York, Liège, June 23, 1921.

⁴ Cf. pp. 11-12; see also Falsey, F. A., "The Metric Fallacy," pp. 1 and 2.

merce from the French Minister of Commerce, Industry, and Labor, an excerpt from which is here given:

My Department has been obliged, upon several occasions, to give instructions to the Service for the verification of weights and measures to effect the total suppression of prohibited measures or weights by the seizure of these irregular objects, according to the law of July 4, 1837. In spite of all its efforts the Service has not yet been able to obtain the desired result, and this situation appears to proceed from the persistence with which certain trade bodies continue to make use of the prohibited denominations, and to induce in this manner the employment of the forbidden weights or measures.¹

The view of English proponents on this whole matter is summed up in the following quotation:

The statement that the countries named (France, Germany, Austria-Hungary, Norway, Sweden, Finland, Holland, Belgium, Switzerland, Spain, Portugal, Italy, Servia, Roumania, Bulgaria, Greece, the Ottoman Empire, Japan, China [thirty-eight ports], Egypt, Mexico, the Central American and South American countries, the dependencies of the above mentioned countries and the Latin acquisitions of the United States) "customarily employ the metric system" is a pure assumption. No evidence of this is submitted, while on the contrary, all available evidence shows that in some of these countries the system is used but little, and in none of them is it universal.²

In further answer to the metric contention that various metric countries have easily and quickly secured, by the adoption of the metric system, uniformity of weights and measures and the suppression of the many and varied local systems in the country, proponents of the English system call attention to two facts. First, they point out that even where a substantial degree of uniformity exists in a metric country today, experience of all metric countries proves that a long transition period ranging from 25 to 100 years is necessarily involved in making a change in systems, during which period the country is forced to contend with a confusion resulting from the extensive use of local measures along with the attempted enforcement of the compulsory metric law. France is pointed to as a preëminent example of such difficulty, confusion, and lack of uniformity. In the next place, proponents of the English system point out that whereas most metric countries had no national uniformity of weights and measures before the metric system was adopted, the United States now has and has had for many years, a standardized and thoroughly unified system which is solidly incorporated in its manufacturing and basic industries and business life, and deeply ingrained in the habits of the people. For these reasons, English proponents point out, if it has been difficult to suppress older

¹ Letter of M. Gaston Doumergue, Minister of Commerce, Industry and Labor, France, Division of Personnel and Records, Bureau I, Circular 111, "Weights and Measures. Prohibited Denominations," April 11, 1906.

² American Society of Mechanical Engineers. Report No. 972, Appendix XII, p. 698.

units in other countries which have adopted the metric system, still greater difficulty is to be expected in the United States. The following passage expresses the attitude of English advocates on this point:

In France at the time of the adoption of the metric system not a solitary power cotton spindle was in operation. Now we have 23,000,000 in this country. Over 6,000,000 have been installed there in 114 years. Here more than 6,000,000 spindles have been started in the South alone in 24 years. Then France was but three-fourths the size of Texas; now we have an area of 19 times that of France. Their population has increased 12,000,000 in 110 years; ours has increased 12,000,000 in 10 years. There the new system was forced at the point of the bayonet on a people accustomed to obedience to arbitrary law; here people firmly believe that they have the right to weigh things as they choose. There the attempt has failed with all the conditions favoring a change; here failure is certain, because every condition is adverse to change.¹

The difficulty of a change is obvious, they say, when it is considered that it would completely disrupt established habits of everyday life, in culinary and household matters, in retail trading and shopping, in building, in transportation, etc.² The following illustrates some of the ways in which, according to the proponents of the English system, the use of the metric system would affect every-day activities:

To the housewife would daily come the problem of deciding between butter offered by one dealer at \$.78 per pound and by another at \$1.75 per kilo. The size of every town lot and every plot of ground everywhere would be expressed in indeterminate decimals. Hectares and ares (metric measures for area) are scientific and symmetrical but they do not fit our lands any more than square hats would fit our heads. Metric measures might in some instances become fixed; for example, the quart basket of berries containing 67 cubic inches would probably soon give way to the liter basket of 61 cubic inches, but for the most part the old measures would stick as they have invariably done in other countries, and instead of one system for each class of transactions we should have two—incommensurable and discordant.³

And again:

A person standing five feet ten inches becomes 1.778 meters tall, without any change in height. A mile a minute, or sixty miles an hour becomes 1.609 kilometers a minute, or 96.54 kilometers an hour, without any change in speed. A town lot 60 feet front and 120 feet deep with an area of 7,200 square feet, becomes 18.29 meters front and 36.58 meters deep, with an area of 668.9 square meters, without any change in size. Nine thousand pounds of coal at \$11 a ton, plus \$.40 for carrying in, costing \$51.30, becomes 4,082 kilograms at \$12.12½ per tonneau, plus \$.44 for carrying in, costs the same amount, \$51.30. . . . All the standards of the innumerable transactions at retail would be changed. Dress goods at 50 cents a

¹ Dale, Samuel S. Testimony in Hearings before House Committee on Coinage, Weights and Measures, 59th Congress, 1st Session, 1904, pp. 37-56.

² *Iron Age*, "Metric Chaos in Daily Life," March 4, 1920, p. 679.

³ Toledo Scale Company, Toledo, Ohio, "Metric System of Weights and Measures vs. English System," *Toledo System*, April 3, 1920, p. 4.

yard becomes 54.7 cents a meter until the price rises to an easy figure. A bed sheet $2\frac{1}{2}$ yards long becomes 228 $\frac{1}{2}$ centimeters without any change in length. A man wearing what is now a No. 16 collar will wear a No. 40 $\frac{1}{2}$ collar by the centimeter size and without any enlargement of his neck. A lady who now wears a No. 4 shoe will have to call for a pair of No. 25 $\frac{1}{2}$ when she orders a new pair by the scientific scale. A pound of butter at \$.90 becomes .454 kilogram at \$1.98 a kilogram. . . . These illustrations of the workings of the scientific program of weights and measures could be continued indefinitely, for it affects everybody and everything.¹

The importance of established habits in the use of systems of weights and measures, English proponents continue, is not often realized by the individual, for the simple reason that the system has become a part of his automatic thought activity. The various units of length, weight and capacity visualize to him "things, descriptions, expressions, conditions, relations, events, values, abstract facts and natural laws. His familiarity with them has become a habit and he uses them subconsciously. They have become, in fact, a part of his mental equipment. . . . The change from one system of weights and measures to another, therefore, involves . . . the tremendous task of changing the daily habits of the people."² As an illustration of the mental readjustment necessary, they list a few familiar English units with their metric equivalents as follows:

One mile equals	1.60934 kilometers
One pound equals	.45359 kilograms
One quart equals	.94636 liters

How long would it take, they ask, before any of us could think in these unfamiliar units and use them correctly without constant reference to tables of equivalents? The chief difficulty, it is held, in the adoption of the metric system in Latin America has been and is this psychological difficulty of learning to think or visualize in strange units.³ It makes little difference, English proponents contend, whether the people be ignorant or intelligent as regards the difficulty of thinking in a new system, and this difficulty is most decidedly an argument against a change.

In the second place, admitting⁴ that it might not be a great task to build up a metric literature, since in the beginning the rules, tables, formulæ and data now printed in metric countries could be reproduced, the big job, English proponents contend, would be to produce the literature of the transition period. This would involve the enormous task of translating and revising the English literature on the mechanical sciences and on engineering

¹ Dale, Samuel S., *Boston Evening Record*, January 13, 1919.

² Stutz, C. C. "The English and the Metric Measuring System," *American Machinist*, November 11, 1920; Cf. also "The Sinister Metric System," Editorial, *Fire-Engineer*, April, 1920; and "Pan-American Weights and Measures," *Testes*, November, 1920.

³ Halsey, F. A., and Dale, S., "The Metric Fallacy," p. 5.

⁴ *Ibid.*, p. 693-4.

which has accumulated during the past hundred years. Every book, newspaper, trade journal and catalog, current or filed for reference in the United States, and in which there is any allusion to weights and measures, would become useless under such a change, even during the transitional period.¹ The records, drawings, plans, etc., preserved for future use in manufacturing establishments, which number many thousands, are all in the English system and it would be impossible or enormously expensive to redraw or convert them.² The transition literature would have to include, in the tables of beams, for instance, all the existing standard sizes in even inches for depth with their corresponding metric equivalents to the nearest tenth of a millimeter, together with the dimensions, both English and metric, of length, breadth of flange, and thickness of web, the weight per yard and per meter in pounds and kilograms and the coefficients for computing strength in both systems. In the revising of this vast technical literature errors would be multiplied, the volume of the literature would be doubled, and it would finally have to be discarded after the transition was completed.³

This is but an illustration, English proponents contend, of the vast confusion which would result in all fields from the introduction of the metric system. The change, so far from achieving uniformity and thereby being welcomed and made easy, would, they claim, create difficulties which it would be almost impossible to overcome without a long period of disturbance. In the last analysis, since it would be impossible to dislodge from American life the established and existing system of weights and measures, the encouragement or enforcement of new units would only serve to create a dual system.⁴ Proponents of the English system sum up their attitude in this connection with the following statement of John Quincy Adams, made in 1821:

Is your object uniformity? Then before you change any part of your system, such as it is, compare the uniformity that you must lose with the uniformity that you may gain by the alteration. At this hour fifteen millions of Britons who, in the next generation, may be twenty, and ten millions of Americans, who in less time will be as many, have the same legal system of weights and measures. . . . Precious, indeed, must be that uniformity, the mere promise of which, obtained by an alteration of the law, would more than compensate for the abandonment of this.⁵

¹ American Society of Mechanical Engineers. Report No. 972, Appendix IX; also "The Metric System: A Big Job for a Literary Engineer," a letter condensed from *Engineer News*, February 19, 1903, pp. 691-5.

² United States. 58th Congress. Hearings before House Committee on Coinage, Weights and Measures, p. 199.

³ *Idem*.

⁴ *Machinery*, "Inches vs. Millimeters," April and May, 1920; also Stutz, C. C., "The English and the Metric Measuring System," *American Machinist*, November 11, 1920; also Fulton, A. S., Vice-President of the International Motor Co., "Compulsory Metric System Bill," *Iron Age*, January 29, 1920, p. 361.

⁵ Adams, John Quincy, "Report on Weights and Measures," Washington, 1821, p. 47.

The difficulties and confusion involved in a compulsory change, English proponents maintain finally, cannot be mitigated by any initial limitation of compulsory legislation to certain fields and its gradual extension as suggested by metric proponents. Bills requiring the use of the metric system in government departments, such as have been considered time and again in congressional committees as a means of gradually introducing the system in this country, English advocates assert, are merely disguised measures for compelling the use of the system generally. Such legislation would compel the millions of farmers in the country, for instance, to learn the metric system in order to understand and derive any benefit from bulletins and publications of the Department of Agriculture in which the metric terms would have to be used. It would in effect drive manufacturers and business men at large to adopt the system not only in transactions with the Government but in their own manufacturing processes. The Government is one of the biggest consumers of goods in the country, it is pointed out, and the bidding on government work affects the larger part of the nation's manufacturers and tradesmen. If an article is to be described in metric terms, the very nature of modern manufacturing processes will require in the main that it be made in metric units, as is shown in the following section, and the cost of making such an article would therefore involve a portion of the cost of new gauges and other metric equipment required. In bidding on government work business men and manufacturers would add to their cost the cost of the new equipment, tools, scales, gauges; and in order to recover the total cost of such equipment, which is a very large proportion of the initial cost of manufacture, if the Government did not bear it wholly it would be necessary for the manufacturer to continue manufacturing articles of the same type in metric units. The requirement of the metric system in government work would therefore as effectually force the system on the manufacturers and business men of the country as any general compulsory law would.

In any case, English advocates contend, no compulsory law of any kind would be necessary if the metric system possessed the advantages claimed for it. It is already permissible, they point out, for any one who wishes to use the metric system to do so, and if the system had any merits which recommended it conclusively to the public, no difficulties would long stand in the way of its adoption and no gradual extension of compulsion would be needed. Standards of screw and pipe threads, for instance, were freely adopted when the advantages of them were recognized, and manufacturers have voluntarily scrapped thousands of dollars worth of machinery when it was deemed desirable to do so.¹ In short, if the metric system were a superior system

¹ United States. 56th Congress. Hearings before House Committee on Coinage, etc., p. 46; also Hearings, Feb. 6, 1902, pp. 8, 9.

it would long since have come into use without the necessity of compulsory law.

To sum up, English proponents maintain that the experience of other countries conclusively shows that the difficulties arising from a drastic change in the habits of the people, from the necessity of revising the technical literature of the country, and from the confusion incident to the use of two systems side by side during the long period of transition necessary, would be insurmountable no matter what form of compulsory law were adopted to compel the use of the metric system, and the fact that compulsory law is invariably required to bring about a change, as shown by the experience of other countries, demonstrates that the system has no advantages which would lead people to adopt it voluntarily.

These difficulties, the long period of transition and the confusion that could not be avoided, English proponents say finally, become especially clear when one considers the situation which would result from the change with regard to the mechanical standards around which the industries of the United States have developed.

TO WHAT EXTENT AND HOW WOULD A CHANGE TO THE METRIC SYSTEM INVOLVE THE DESTRUCTION OF ESTABLISHED MECHANICAL STANDARDS?

As was pointed out in Part II, Chapter VIII, and in the preceding chapter of this part, the question of the relation of a change in systems to the mechanical standards which modern machine industry has developed is of central importance in considering the practicability of making such a change. This is admitted by both English and metric proponents. Machine industry in the United States is based practically wholly upon the English system, machine parts, tools, fixtures, drawings, specifications, manufacturing processes of every description being closely bound up with the English units. The question here is, how and to what extent would it be necessary to alter or discard this mechanical equipment?

Metric

Metric proponents maintain that a change to the metric system would not necessarily mean the destruction and discarding of the present system of mechanical standards or the equipment embodying it; that it would involve in large part merely the expression of present standards in metric terms; and that in so far as any alteration or destruction became advisable, it could be effected gradually and without confusion as the equipment in question wore out and had to be replaced.¹

¹ Such a view is expressed by Mr. T. H. Miller, Works Manager of the DeLaval Separator Company, in an article: "The Metric System in an American Shop,"

This is true, they say, because in the system of mechanical standards which has been developed in English units, dimensions are more nominal than real. The system of sizes is largely arbitrary and serves mainly to designate various pieces for convenience. In practically all cases integral metric figures could be substituted for the current designations, which figures would, it is held, as closely approximate the actual dimensions as the existing nominal English dimensions do. Measurement of pipe threads and similar standards would not have to be changed, declares Mr. Fred J. Miller,¹ past president of the American Society of Mechanical Engineers, but could be designated by letters or expressed either in inch terms or metric terms and the result would be indistinguishable. The same is true, according to Mr. Miller, of all our standards for taper shanks, tools, milling machine arbors and the like, which will be preserved, he says, under any conceivable rational adoption of the metric system, and which can be as well preserved when their dimensions are stated in metric terms as when stated in English terms. The chief effect of a change to the metric system, therefore, would be only in descriptions of goods in catalogs. No change of actual dimensions, it is maintained, would be required; and for ordinary uses, standard parts and equipment might very well retain their present names or designations.

The following quotation from Dr. Arthur E. Kennelly, Professor of Electrical Engineering, Harvard University and Massachusetts Institute of Technology,² illustrates the metric point of view in this respect:

Some go so far as to assert that the change would necessitate the rejection and destruction of a large amount of machinery and machine tools throughout the country. There seems to be no warrant for the latter belief. In France, Germany, Italy and other countries which have adopted the metric system, the history of the change indicates that the only machines destroyed or put out of commission by the change were those which made the old measures. A machine for turning out foot rules or pound weights would clearly call for considerable modification or even for rejection. Such special machines would, however, be relatively very few, and the new business involved in making the new measures would be likely to compensate for this loss. No ordinary machines, such as lathes, drills, shapers, etc., would have to be changed if the metric system were adopted, because no one would be likely to insist upon having things changed to exact even sizes in the new measurements. The same old tools would go on making the same old things; but the numerical values of the sizes made would be altered. At the present

appearing in the August, 1920, issue of *Machinery*. Mr. Miller explained in detail the successful experience of that company in changing to the metric system without encountering any serious difficulties or much cost. It did not, he stated, involve the destruction or discarding of many mechanical standards, designs, patterns, tools, etc., but necessitated only the designation of existing dimensions in metric units. The old equipment, as it wore out, was gradually replaced by new equipment made to integral metric dimensions.

¹ Miller, Fred J., paper presented before annual meeting, American Metric Association, December 27, 1919.

² *Scientific Monthly*, "The Metric System from the Standpoint of Electrical Engineering," March, 1917, p. 194.

time, the sizes of parts are seldom exact unit sizes. They have ordinarily to be expressed in units and decimals, especially when precision is required; so that, under the new system, there would be merely a re-cataloging under new units and decimals.

The expression of present English dimensions in metric terms, metric proponents continue, would not involve any greater use of complex decimal fractions than is customary at present. In mechanical practice, they point out, workmen commonly work to the thousandth and ten-thousandth of the inch, and any translation of sizes into metric terms would require no greater number of decimal places for the designation. In any case, metric proponents say, in modern machine industries most work is turned out on the gauge system and the workmen do not have to concern themselves with the dimensions, whether metric or English.¹ This is instanced, they claim, by the experience of the Baldwin Locomotive Works, where locomotives are said to have been built in metric units for the French Government without requiring any change in machinery.

Wherever it might be deemed more desirable, however, to adopt finally new absolute metric standards in tools and machinery, metric proponents say, this need not be done immediately but can be accomplished as the tools and machines wear out in course of use. The life of machine tools, they point out, is not long and frequent replacement is normally necessary in industry. Moreover, they say, English proponents themselves admit that modern manufacturers think nothing of scrapping tens of thousands of dollars worth of even good equipment when it appears advantageous to replace it by better. In short, metric proponents contend, a change to the metric system would create no abnormal situation in industry as regards equipment and machine standards.

English

Proponents of the English system maintain, on the contrary, that a genuine adoption of the metric system in this country would require the immediate destruction and discarding of the existing system of mechanical standards and the replacement of the equipment embodying it. In the first place, they say, the application of metric designations to the important English standards is impracticable and in any event would be quite pointless because it could hardly be considered an adoption of the metric system and, secondly, it would be impossible gradually to substitute new metric standards and equipment for the old as the latter wore out without catastrophic confusion to industrial processes through a protracted period.² Even if the change were

¹ American Society of Mechanical Engineers. Report No. 972, p. 640.

² An interesting and detailed discussion of this problem appears in an article, "The Metric Agitation," by Mr. Luther D. Burlingame, Industrial Superintendent of Brown & Sharpe Company, published in *Machinery*, July, 1916. This article explains in detail some of the changes in basic mechanical standards involved and the difficulties attending such changes in substituting the metric for the English system of measurement.

made suddenly, it is contended further, a long transition period fraught with confusion and disorder would inevitably follow.

If the United States is to adopt the metric system, English advocates declare,¹ it will not be possible to use metric designations for old sizes. Industry would have to adopt metric standards, though the old standards would have to be retained alongside the new for repairs on old machines. There would be, for instance, a standard mandrel whose dimension is 25 millimeters for the manufacture of new machines and there would also be a 1" mandrel, which might be called 25.4 millimeters, for repair work on old machines. If we were to continue to make equipment to existing standards and merely apply metric designations as was done in the case of the "metric" locomotives built by the Baldwin Locomotive Works, this would be neither the adoption nor the use of the metric system. It would merely be expressing in terms of the metric system, with which the English is incommensurable, an existing standard dimension which is integral and exact in the English system. Such a change, it is held, besides being quite meaningless, would, even if feasible, simply introduce confusion and error through calling things by wrong names and in learning new designations, such as 9.53 millimeters as the equivalent of $\frac{3}{8}$ inch. Furthermore, it is contended, the very nature of modern manufacturing processes makes such a procedure impossible except in a very limited way.

As evidence of the impossibility of abandoning present designations of machine-shop standard sizes and expressing them in the nearest equivalent in metric dimensions, English advocates quote the following:²

Such a course has not been pursued even by those shops which have adopted the system either in whole or in part. The injector department of William Sellers & Co., the Waltham Watch Co., Willans and Robinson, and other manufacturers whose use of the metric system has been cited, did not introduce it by retaining old standard sizes and giving them new names, but by the abandonment of the English standards.

How is it possible that the metric system can be introduced into a shop in the way proposed? Here are a few of the difficulties: A standard gear-wheel size is six diametral pitch, meaning six teeth to each inch of diameter. Will any one give it a new name and say six teeth per 25.4 millimeters or twenty-four teeth per 101.6 millimeters?

A $1\frac{1}{4}$ inch bolt has seven threads to an inch. Shall we call it a 31.75 millimeter bolt and say it has seven threads to each 25.4 millimeters, or shall we call it a 32-millimeter bolt, scant, and say its pitch is 3.63 millimeters nearly?

¹ American Society of Mechanical Engineers. Report No. 972, pp. 641-43.

² *Idem.*, Appendix II, p. 683; see also testimony of William Sellers in Hearings before House Committee on Coinage, etc., 59th Congress, 1st Session, 1904, pp. 91-119.

There is not a single pitch in the metric system that will fit the United States system now so universally used. An example of this is the 12-pitch gear which is used by thousands in this country. The closest pitch to this in the metric system is module 2. These gears will not run together because the thickness of the metric tooth measured along the pitch circle is .124 inch, while that of the 12-pitch tooth is .131 inch. In order to run these gears together it would be necessary either to change the 2 module to 1.889 module, or to change our standard to 2 module. It would mean that millions of gears on hand would no longer be interchangeable, that millions of dollars would have to be expended for changing over and rebuilding gear cutters, and that the necessary gauges for checking the product would become obsolete, except for the purpose of repairing old gearing.

A common automobile cylinder dimension is that of the $3\frac{3}{4}$ in. bore. It is a standard size and is turned out by one concern alone in quantities of 12,000 per day. This standard is so well established that pistons and rings can be secured to fit it in every city in the United States. The metric translation of this size is 95.25 mm. Would our manufacturers be willing to adopt, or would other countries be willing to adopt, this size of 95.25 mm., or would it not be found necessary to adopt a 95-mm. bore? If 95 mm. should become the standard, it is not difficult to estimate the effect on the manufacturer, who would be forced to scrap his tools, fixtures, jigs, etc.

The United States makes more than one-half of the screw products of the world. Our system is the most interchangeable of any of the systems which are in use at the present time. The bolts and nuts made by one manufacturer are readily interchangeable with the corresponding sizes made by another manufacturer. It has even been found that our standard 1 inch, 8-threads-per-inch bolts and nuts can be used with 1 inch, 8-threads-per-inch bolts and nuts of the English Whitworth system.

In the metric system there is not a single diameter of bolt or pitch which will fit those now being extensively made in the United States. The pitches in the English system are expressed in terms of a certain number of threads per inch of length; while in the metric system they are measured from a given point on one thread to a corresponding point on the next thread, and under this system all fine threads become an awkward fraction of a millimeter.¹

In other words, English proponents maintain, it would prove necessary, whether sooner or later, to supersede present standardized tools and parts by new tools and parts made to absolute metric dimensions. This means, they continue, the ultimate destruction of the established system of standards and the abandonment of current interchangeable parts.

Some conception of the difficulties which would be involved in such a destruction of standards is given in the following observation regarding some of the things which it is claimed would have to be altered:

All rules, tables and formulæ used in calculations involving measures of length. All drawings of manufactured articles. All

¹ Chamber of Commerce, Cleveland, Ohio, "The Metric System: Report in Opposition to its Compulsory Adoption," June, 1920, pp. 7 and 8.

measuring scales and measuring tools, calipers, verniers, etc. All drills, taps, reamers, screw-threads, boring bars, milling cutters, mandrels, standard plugs and rings, and shop tools, gauges, templates, etc., that are based on this standard unit. All machine tools, leading screws of lathes, and feed and elevating screws of milling machines, planer heads, etc. All graduated heads of feeding screws. All interchangeable parts of the things made in machine shops, which things are distributed all over the world. All gear wheels, gear cutters and gear patterns. All pulleys and shafting, hangers, couplings, bushings, and bearings. All merchant sizes of bars and plates of iron, steel and other metals. All structural iron shapes. All merchant sizes of pipe, pipe flanges, pipe fittings, valves, and the screw-threads of the same. All bolts, nuts, rivets, keys. Locomotives, cars, railroads and their appurtenances, all marine and stationary engines, all ships. All parts kept in stock for repair or replacement of these things.

As to the number of these things in use throughout the world, produced by the shops of the United States and Great Britain, they are more than the similar things produced based on all other systems of measurement in all the rest of the world combined. As to the number of people engaged in making these things in the United States and Great Britain, they are more than the number of people engaged in making similar things in all the rest of the world combined. As to the number of people using these things throughout the world, they comprise more, also, than those who use similar things based on all other systems of measurement combined.¹

Nor, English proponents continue, is the gradual substitution of new metric standards a practicable solution. The assertion which pro-metrics make, based upon the fact that scales, tools and machines are constantly wearing out and have to be abandoned and replaced by new machinery, does not, they point out, mitigate the difficulties involved in a change to the metric system. For instance, they ask,² when would the opportunity be afforded to change the shape and size of a milling cutter adapted to cut teeth of six pitch (that is, six teeth per inch of diameter) to any integral metric designation? With respect to the hundreds of thousands of matched gear wheels of standard diametral pitches which are now in use, how is it possible to effect even a modicum of transformation without tremendous confusion? The same applies to all screw-thread standards, pipes, bolts, turned shaftings, etc. Furthermore, it is maintained that even if equipment could be replaced gradually, this would be wasteful and costly because stocks would have to be doubled or greatly increased so that sets of standard parts in both systems would be always available.

The position of English advocates with regard to the impracticability of a gradual adoption of the metric system in connection with existing standards is summarized in the following statement:

¹ American Society of Mechanical Engineers. Report No. 972, Section V., pp. 668 and 670.

² *Idem.*, Section 17, p. 645.

This would involve making machines for years with part English and part metric dimensions, with constant change as the English dimensions are dropped—that is, until the transition is complete. During this period there could be no standardized production, but constant change. We cannot regard the use of both systems on the same machine as a thing to be tolerated, much less deliberately encouraged. To continue existing units on old machines while adopting the metric units on new ones helps matters but little, as in all lines of machines many parts are common to different sizes. Moreover the whole question is based on the idea that the sacrifice of the change is measured by the cost of buying new small tools. On the contrary, the chief sacrifice is in the changing of standardized things—in the throwing away of standards, the value of which we will not know until we lose them. The value of shafting and pulley standards, for example, lies in the fact that by reason of them shafting and pulleys may be made in large quantities and therefore cheaply; that because their fitting is insured, they can be made in advance and sold from stock as needed instead of being made to order at increased cost and delay; that pulleys can be changed about as needed, and if thrown out of use become again available for any shaft of their size, whenever wanted. Who would think of estimating the value of shafting standards to the country, by the value of the turning and boring tools and gauges in pulley and shafting factories? Nevertheless, that is exactly what you do when you tacitly assume that the cost of changing our shop standards is measured by the expense of new tools. Imagine, if you can, the confusion that would prevail if pulleys and shafting had never been standardized, and you will begin to understand how ridiculous is your assumption that the cost of this change can be measured by the cost of small tools. Into the loss due to the destruction of standards the element of time does not enter, and we therefore regard the idea of a gradual change as simply postponing and refusing to face the difficulties of the problem.¹

In short, it is contended, a change to the metric system would involve the inevitable discarding as suddenly as possible of both the designations pertaining to standardized equipment and also the vast store of standard equipment itself.

Furthermore, English proponents contend, such destruction of mechanical standards would necessarily be followed by a long aftermath of confusion and disorder—a hundred years or more of laborious rebuilding of interchangeable standardized equipment in a new system. These consequences would be very serious, they say, and this should be evident to everyone when it is considered that the English system has had centuries of use with no tendency to change and that the standardization which exists has been painstakingly built up in this system. It is pointed out that the English foot and inch, especially the latter, are fixed in existing measuring instruments, gauges, tools, patterns, machines, machine products, buildings, building equipment, railroad equipment, manufacturing processes, and technical literature. Whatever advantages exist in English mechanical standards are due to these

¹ *American Machinist*, "Action of Cincinnati Manufacturers on Metric System," November 27, 1902; also American Society of Mechanical Engineers, Report No. 972, p. 697.

facts and are not only advantages of mechanical convenience and economy, but involve vastly important trade considerations as well. The making of articles in standard sizes in large quantities, made possible by the use of the English gauge and machine tool, has been developed to a high degree in the United States. This is the reason for her industrial pre-eminence. The adoption of the metric system in France and Germany, English proponents continue, came before the development of modern gauges, tools and dies, and even in these countries today English standards are utilized to a large extent. In fact, mechanical equipment throughout the world is in large part based upon English standards, for which reason the leadership which the United States and Great Britain hold in the manufacture of mechanical products would be seriously affected by the change in systems of weights and measures.

To sum up, English proponents contend, first, that all available evidence based upon the experience of other countries indicates that the substitution of metric designations for existing sizes and the actual replacement of English with new metric equipment is impracticable, and secondly, that if the United States is contemplating a change in systems it must face the fact of the destruction of existing mechanical standards. In addition, they insist that following the change there would necessarily be a long aftermath during which the mechanical industries of the country would suffer from a tremendous confusion and the laborious undertaking of rebuilding new standards in another system.

Nor would the destruction of existing standards and the long aftermath of confusion be the only effects to be taken into account in considering the practicability of a change, English proponents assert. A complete and thorough change would involve, as is pointed out in the next section, an expenditure which would constitute an overwhelming burden upon industry.

WOULD THE COST OF A CHANGE TO THE METRIC SYSTEM IN THE UNITED STATES BE PROHIBITIVE?

Metric

Metric proponents contend in general that the cost of a change to the metric system has been greatly over-estimated. Such a change would involve, they assert, merely the translation of literature and catalogs, which, in view of the existing metric literature, would not be difficult,¹ and the replacement of present weights, measures and scales, affecting chiefly the field of domestic trade, rather than any serious destruction of equipment; and whatever the cost in this connection might be, it would be more than compensated for by the elimination of the loss which they claim is at

¹ See p. 164.

present sustained by the United States through the use of the present system.

One authority¹ states the metric attitude regarding cost as follows:

The cost would be essentially the expense of learning the new system and of becoming familiar with it . . . of recataloging, re-estimating, altering the sizes of parcels and of purchases, together with the expense of the mistakes that would naturally occur during the transition period. . . . All changes for the better involve some inconvenience and expense. The national and international advantages would, it is felt, go far beyond defraying the necessary inconvenience and expense of changing the numerical scales and measures of the things which we use.

With regard to the cost of the extra weighing and measuring instruments necessary, this item has been estimated to require an expenditure of only about \$10,000,000,² and it has been suggested that the State or Federal Government would probably reimburse retail dealers in this regard. Some metric proponents say that merely the weights and the graduation plates on scales need to be changed and that this expense would be trifling. Solid and liquid measures are little used, it is claimed, and in most cases could easily be re-marked to liter equivalents.³ Progressive retailers during the past few years are said to have scrapped not only their weights but their scales in favor of direct reading balances, which balances it is claimed can be adapted to the new weights for a relatively small sum. The total cost of any change in weights, metric proponents say,⁴ would in any case be a small item in average business expenditure.

Metric advocates present various estimates of the cost of a change in different fields.⁵ Such figures, as a rule relatively small, are of course merely estimates by individuals as to the probable cost that would be incurred, based on personal opinion, and should be considered only in that light. One such estimate places the total expense of making the change in the United States at \$600,000,000.⁶

Metric proponents maintain, moreover, that whatever cost the change involves would be more than compensated for by the savings resulting from it. The simplicity and convenience claimed

¹ Kennelly, Arthur E., "The Metric System from the Standpoint of Electrical Engineering," *Scientific Monthly*, March, 1917, p. 195.

² Collins, Dr. J. V., *Scientific Monthly*, December, 1915.

³ Stubbs, A. J., Member of British Institute of Civil and Electrical Engineers, *Decimal Educator*, September, 1918, p. 25.

⁴ *Idem.*, p. 25; see also United States, 56th Congress, Hearings before House Committee on Coinage, etc., pp. 9, 10.

⁵ World Trade Club. Pamphlet, "An Evening with the World Trade Club," p. 17. Great Britain. "Final Report of Committee on Commercial and Industrial Policy After the War," 1918, p. 55; Stratton, Samuel W., "Metric System in Export Trade," Report to the International High Commission. Senate Document No. 241, 64th Congress, 1st Session, January 6, 1916, p. 8.

⁶ Collins, Dr. J. V., *loc. cit.*

for the metric system indicates, they say, that reëducation of the people in the use of the system would be more likely to involve a gain than a loss, since the present use of the English system is, it is held, wasteful and expensive. Metric proponents present various estimates of the loss resulting from the use of the English system and of the savings which they claim would result from adopting the metric units.¹ One such estimate² places the total annual loss through the continued use of the English system in the United States, at \$315,000,000, which includes:

Loss of time in making reductions between systems....	\$5,000,000
Loss of profit from foreign trade due to failure to manufacture goods to metric units.....	20,000,000
Cost in school taxes of keeping 2½ millions of children in school two-thirds of the year.....	50,000,000
Cost to parents for support of 1½ millions of children two-thirds of a year.....	100,000,000
Cost through loss of productive power of 1½ millions of youths for two-thirds of a year.....	75,000,000
Loss of earning power through children dropping out of school on account of difficulties of arithmetic as now taught	25,000,000
Loss of time in arithmetical calculation by one million men in trade, industry and manufacture, at 10 cents per day each	30,000,000
Cost of extra weighing and measuring instruments needed for sundry tables.....	10,000,000

Another proponent of the system sets the annual loss as high as \$750,000,000.³

English

Proponents of the English system ridicule the assertion of the pro-metrics that the United States is suffering a loss by holding fast to the English system. They insist that the arguments in the chapter on intrinsic merits have proved conclusively that the English system is intrinsically superior to the metric and that, with respect to the alleged facility in computing work, the general use today of mechanical devices, such as calculating machines, logarithmic tables, slide-rules and the like, have made it just as easy to calculate with one system as with the other. Nor do the pro-metrics mention the important fact, advocates of the English system continue, that the confusion and fraud following a change in systems would result in a tremendous economic and pecuniary loss.

In general English proponents maintain that the cost of a change to the metric system in the United States would be so staggering as to be prohibitive. It would, they say, involve not merely

¹ World Trade Club. Pamphlet, "What Will Metric Standardization Cost?" pp. 74-81.

² Collins, Dr. J. V., *loc. cit.*

³ World Trade Club. Pamphlet, "What Will Metric Standardization Cost?" p. 76.

translation and revision of literature¹ but enormous and costly changes in material and equipment and slow and difficult re-education of the people. It would involve, they contend, a change of every public and private record of measurements in the United States² and disturbance of industrial and business life, the cost of which it is impossible to estimate.³ The change in weighing and measuring instruments would not only be expensive⁴ but would require a change in prices and would result in a tendency on the part of tradesmen to turn to their own advantage the adjustment to round numbers which becomes inevitable when prices are translated from one system to another.⁵ The period of education in the new system would therefore incite to overcharging and fraud, resulting in an enormous cost to the consumer.

The actual material cost of replacing weighing scales and measuring instruments would, without question, be great, English proponents insist, although no authoritative estimates have been made on this score. As a specific instance based upon ascertained data, it is cited⁶ that in 1877, the Post Office Department, which then had 38,000 post offices compared with 51,000 in 1921, estimated that it would cost approximately \$166,000 to replace merely the scales then in use in the post offices alone. When it is considered that every one of the 1,250,000 retail and wholesale dealers in the United States constantly uses weighing scales or measuring instruments, some idea of the material expense in this respect can be had. This cost, however, it is claimed, is only the least of the material expense that a change in systems would involve.

The industrial leadership of the United States, English proponents point out, has been due to large-scale standardized production at low cost, which has been secured by the development of expensive special equipment, metal patterns, metal gauges, jigs, templates, punches and dies accurate to within the ten-thousandth part of an inch, all of which enable the duplication of any piece at any time. This equipment devoted solely to the purpose of securing accuracy and low cost of production is valued at from 20% to 33⅓% of the entire machinery inventory of a factory. In other words, English advocates contend, a comparatively small plant with a machinery and pattern inventory of \$100,000 would have to replace at least \$20,000 worth of that class of equipment under a compulsory metric change. The cost would thus, they say, run into hundreds of millions for the manufacturers

¹ Cf. pp. 170-171.

² *American Machinist*, "What Real He-Men Think of the Metric System," February 5, 1920, p. 308. Letter of Lodge and Shipley Machine Tool Co., Cincinnati, to Editor, January 20, 1920.

³ Sharpe, H. D. "The Threat of the Metric System," *Machinery*, April, 1920.

⁴ Halsey, F. A., a paper on "The Cost of a Change."

⁵ Report of Metric Committee, Appointed by the Conjoint Board of Scientific Societies of Great Britain, February, 1920, p. 23.

⁶ United States. 46th Congress, 1st Session. House Committee Report No. 14, p. 70.

of the country.¹ The testimony before congressional committees on this subject by manufacturers, some of whom otherwise favored the metric system, English proponents say, shows that this factor of cost due to the alteration of equipment, and disproportionate to any advantages derivable from the change, is the determining consideration against the metric system's adoption in this country.²

Few manufacturers have worked out, in itemized fashion, their estimate of the cost of changing from the English to the metric system. A large Cleveland manufacturing establishment³ has made an estimate involving such items as the cost in publicity and sales, the cost in the billing and accounting and shipping departments, the cost in the purchasing department, and the cost in the production department. The total estimate of the cost of a change to this concern is \$473,965, on a capitalization of \$1,000,000. A Cincinnati firm with a capitalization of about \$300,000 has estimated that merely the engineering and production cost covering the proposed change from the English to the metric system would be as follows:⁴

Remaking all drawings	\$36,000
Changing patterns	12,000
Cost of new metric tools	27,500
Cost of changing jigs and fixtures (being about 75% of cost if all were made new)	130,500
Change in machine tool equipment	19,000
Cost of training employees to use metric tools	15,000
Cost of extra spoiled work, 1st year	20,000
Cost of extra spoiled work, 2nd year	10,000
Additional labor required due to reduction in efficiency for 2 years	60,000
Changing production and stock room records to conform with metric units	11,000
	\$341,000

The results of a questionnaire sent by the National Industrial Conference Board to associations representing practically every field of manufacture in the United States, developed some interesting information with regard to the expense of a change to the metric system and elicited statements from a number of manufacturers as to the probable cost of the change to them. Over 90% of the plants replying to the questionnaire reported that in their opinion considerable trouble and tremendous expense would be involved in the adoption of the metric system. Several stated that the cost of replacing the equipment that would be necessary would

¹ United States. 58th Congress, 1st Session. Hearings before House Committee on Coinage, Weights and Measures, 1904, pp. 124, 135-141, 255.

² *Idem.*, 56th Congress, 2nd Session, pp. 2 *et seq.*

³ See report of Cleveland Chamber of Commerce on "The Metric System," March 29, 1920, pp. 11-13.

⁴ Letter of Cincinnati firm to American Institute of Weights and Measures, *Iron Age*, March 10, 1921, p. 674.

be almost ruinous. A large number (about 75% of the plants) reported that the adoption of the metric system would require a change in the processing of the product, such as changes in patterns, drawings, specifications, scales, etc., which would be extremely costly. Quotations are here given from a number of representative replies:

"A total change from English to metric measurements in this industry, if made on short notice, say one year, would cost each plant, as a first cost, at least one-third of plant valuation. If five years were given it would still be at least 20% of the plant valuation. In succeeding years the maintenance of tools and parts to keep machinery made to English measurements in repair, the obsolescence of machinery due to inability to secure repair parts, the time consumed in determining whether a hole was threaded to metric or English figures and consequent errors, etc., would amount to figures that would stagger any manager. Also, every man in the shop, particularly among tool makers, has personal tools valued at sometimes several hundred dollars, many of which would be useless after a change."¹

"The expense would be enormous with us. Every article of manufacture with us, which runs into tens of thousands, is based upon gauge measurements. In other words, all product is made to standard gauges, and in the gauge equipment alone, all of which would have to be changed from the English to the metric, the expense would be terrific. In fact, it would necessitate, aside from gauges, a tremendous expense in the necessary work required to adopt the equipment for the production on the metric system."²

"We estimate the cost to our company alone, at \$1,000,000, and the gain at nothing. The cost of the change would be in tools, jigs, drawings and patterns."³

"To change our product to metric measures would involve an exceedingly heavy expense. We estimate roughly that it would cost at least \$150,000."⁴

"It would be extremely difficult to change. We would have to buy new measuring and weighing devices, all of our blue prints would have to be changed to metric units and the entire personnel of the office and factory would have to be educated to use metric units. In addition to entailing considerable expense, it would cause considerable confusion."⁵

"From expense standpoint it would mean practically the ruination of our business, as the cost of changing drawings, patterns, jigs, fixtures and measuring tools would exceed the capital stock issue of \$150,000 of our company

"It must be considered that in changing to the metric system, all of the standards adopted by this company must eventually be destroyed, and practically all mechanical appliances in existence become odd numbers or obsolete, unless, for very many years, both systems are carried on simultaneously at an enormous additional cost."⁶

¹ Winter Brothers, Wrentham, Mass.

² Greenfield Tap, Die and Machine Tool Co., Greenfield, Mass.

³ United Engineering and Foundry Co., Pittsburgh, Pa.

⁴ Gurney Elevator Company, Honesdale, Pa.

⁵ Driver Harris Co., Harrison, N. J.

⁶ Fox Machine Co., Jackson, Mich.

⁷ DeLaval Steam Turbine Co., Trenton, N. J.

"It is obvious that the adoption of the metric system would mean practically the rebuilding or alteration of all the most common types of machines used every day in manufacturing and machine shops and the rebuilding and alteration, where possible, of all of the more expensive tools, tool holders, jigs, fixtures, etc., at a tremendous cost and loss of production during the alterations."¹

"It would not be desirable to have the metric system in any shape or form used in our office or factory. It would be most detrimental and expensive if we should adopt the metric system in any way. The expense would be in proportion to the extent to which it was adopted, but if we should adopt it at 100% it would undoubtedly cost us several hundred thousand dollars, which would be a conservative estimate and we cannot see where we could get any returns due to the change. The expense involved in the changing of all our drawings, jigs, fixtures and the purchase of a large number of new tools would be more than one-quarter of a million dollars with no returns so far as we can see."²

"The change from the English system to the metric would be tremendously expensive as it would necessitate the complete change of scales, weights, measures, etc. . . . and would involve the re-writing, and conversion of innumerable formulas and records which formed the basis of manufacture under the English system."³

Henry R. Towne stated⁴ when a witness before a Congressional committee:

One thousand millions of dollars would not cover the ultimate cost to the manufacturers of the United States of the compulsory adoption of the metric system in the resulting changes in their equipment of machinery, tools and gauges. The cost, it has been estimated, would be from fifty to two hundred dollars per employee. If the number of employees in the metal working and allied trades be assumed to be only 5,000,000, and the cost per employee only \$100, the aggregate would be \$500,000,000.

Recently the American Institute of Weights and Measures made an investigation into the matter of cost which indicates Mr. Towne's estimate to be quite moderate. The aggregate cost of a change to 31 industrial concerns reporting is given as \$21,464,688, or an average cost per worker of \$227.40. On this basis, it is contended, the cost of a change to American industry would be something like two and one quarter billions of dollars.⁵

These views of the enormous cost involved in the change to the metric system are confirmed, English proponents say, by similar

¹ Benjamin Eastwood Co., Paterson, N. J.

² Grand Rapids Brass Co., Grand Rapids, Mich.

³ American Drug Manufacturers' Association, New York City.

⁴ Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," p. 863. Cf. also *Iron Trade Review*, "A Word with the Editor," letter to editor, E. S. Mummont, of Mummont, Dixon & Co., July 17, 1919. Cf. also Toledo Scale Company, Toledo, Ohio. "Metric System of Weights and Measures vs. English System," *Toledo System*, April 3, 1920, p. 4; *San Francisco Business*, "Holding Referendum on the Metric System," pp. 5, 14 and 15.

⁵ American Institute of Weights and Measures. *Bulletins of Publicity Service*, pp. 43, 55, 60; Cf. also C. C. Stutz, "The Cost of the Metric System to the Machinist," *American Machinist*, April 28, 1921.

views of industrialists in Great Britain,¹ the following statement, which also sums up the British view on other phases of cost, being cited as an example:²

Various estimates have been made of the capital cost to this country (Great Britain) of a compulsory change to the metric system of weights and measures. A representative of the textile industries has calculated that if this industry alone were compelled to work entirely in metric measures, the alteration of reeds would cost one and one-half million pounds sterling, and that the cost of the necessary changes in the whole machinery would be thirty to forty million pounds sterling. The Deputy Warden of the Standards has estimated that the cost of new weights and measures for use in retail trade in this country (Great Britain) would be about two million pounds sterling, and certain figures have been put forward for the changes in other industries. There is, however, considerable evidence that the cost of alteration in machinery and tools would probably be less than the value of time which would be lost to industry owing to the difficulty of changing ideas and habits, but this latter loss is obviously very difficult to put into figures. The advocates of the change assert that there would be eventually an enormous saving of time owing to the simplicity of the metric system, but it is noteworthy, that no figures seem to have been put forward to substantiate this claim. Large firms, who, for their own convenience, have adopted the metric system in certain branches of their work, seem content to allow the British system to operate side by side with the metric, which would presumably not be the case if the metric system secured any considerable reduction in costs.

The preceding quotation, English proponents continue, brings out a feature of expense already mentioned which, without question, is of even greater importance than the great material cost a change in systems would involve. This feature is the more or less intangible but nevertheless enormous expense that the aftermath of confusion and disorder would necessarily bring. This aspect of the matter is well expressed in the following statement:

The man who can estimate or indicate in words the value of mechanical standards to this country, . . . does not live. . . . The cost of attempting to change air brake hose couplings is not represented by the value of the tools for making the couplings in the Westinghouse Works, but by the infinite confusion of the railroads in getting from one standard to another. The value of the tools in this case is not many dollars but the cost of the change cannot be found upon any inventory, nor can it be measured by any scale. Similarly, again, the cost of changing our pipe thread standard is not represented by the cost of new taps and dies but by the confusion involved in getting from one standard to another,—a confusion which will last until existing steam, water and gas pipes have disappeared and which will not be lessened by putting off the change until it is brought about at the suggestion and convenience of manufacturers.³

¹ Great Britain. "Final Report of the Committee on Commercial and Industrial Policy after the War," 1918, Chapter X, p. 55.

² Great Britain. Report of Metric Committee Appointed by the Conjoint Board of Scientific Societies, February, 1920, pp. 21 and 22.

³ American Society of Mechanical Engineers. Report No. 972, Section 17, p. 643.

In short, English proponents conclude, since a compulsory change to the metric system under any form of compulsory law would necessarily entail the discarding or alteration of a large part of the basic mechanical equipment of the manufacturing industries of the country, compel the replacement of scales and measuring instruments in use among all classes of people, and require a period of training in the use of the new system, which period would involve errors and reduce efficiency,—the only result of the compulsory adoption of the metric system would be to drag the country into an enormous expenditure and waste without providing any compensatory advantages.

NOTE—In connection with the general question of the practicability and cost of a change to the metric system by compulsory legislation either general in scope or limited to government departments, and in view of the current revision of the Federal revenue and tariff laws, English proponents have recently put special emphasis upon the consideration that such a change would involve the rewriting of the voluminous and extremely complicated mass of legislation relating to internal and customs revenues and the administration of the postal system, in all of which the prevailing English standards are inextricably interwoven. To base the assessment of various postal rates, of taxes of all kinds, and of tariffs, with their intimate connection with industry, on the metric system, they point out, would in the first place destroy at one sweep the detailed and painstaking work of congressional committees and involve a task of translation and revision, expensive, arduous and long in the extreme; would, moreover, require a greatly augmented force of customs and revenue experts to administer the law in the new standards, and would, finally, throw importers, business men, manufacturers and the public generally—in a word, everyone who pays duties or taxes or uses the post office—into a confusion entailing waste and expense beyond measure.

CHAPTER XIV

THE EXTENT AND CHARACTER OF THE DEMAND FOR A CHANGE TO THE METRIC SYS- TEM IN THE UNITED STATES

The purpose of the present chapter is to afford a basis for an answer to the question: "Is there a demand worthy of serious consideration for a change to the metric system in the United States?" In attempting to estimate the importance of the demand for a change, it is necessary to take into consideration not only the general extent of the demand but also its character as indicated by the sources from which it proceeds and the interests most active in it.

Metric.

Metric proponents maintain that there is a strong and growing demand for a change to the metric system in this country. This demand is evidenced, they say, among all classes of people, a growing tendency being noted among the manufacturing industries to favor this system in place of the English. Long lists of names are presented in connection with these contentions, and the opinions of a number of manufacturers are set forth.¹ Finally it is contended that what is true in the United States is likewise true in Great Britain, viz., that there is a widespread demand there also in favor of a change to the metric system.

A pamphlet of the World Trade Club,² an active propaganda organization interested in the compulsory adoption of the metric system, makes the following assertion in an attempt to substantiate the contention that there is a widespread demand in the United States:

Our own conclusion was that only a small percentage of the people in the United States and Great Britain objected to world standardization. To be on the safe side we placed this percentage as high as 10%, although returns indicated that it was much less. The World Trade Club was vindicated in its estimate when on Septem-

¹ For such resolutions and opinions see: "An Evening with the World Trade Club"; "Keep the World War Won"; "Meter-Liter-Gram in World Trade and World War"; "What Will Metric Standardization Cost?"—all pamphlets of World Trade Club, San Francisco; also list of industrial concerns in the United States urging metric adoption, American Metric Association, New York City.

² World Trade Club. Pamphlet, "Who Opposes Meter-Liter-Gram?" p. 2.

ber 15, 1919, a count and grouping was made of 58,234 petitions¹ received by the United States legislators on the subject of meter-liter-gram, and by these legislators referred to the Bureau of Standards, Department of Commerce, Washington, D. C. Out of the total of 58,234, exclusive adoption of metric standardization was advocated by 57,800. Less than 1%, therefore, were opposed.

The same organization presents a more recent analysis of figures covering the number of petitions sent to legislators of the Sixty-seventh Congress up to October 5, 1921. These figures would indicate that the total number of advocates of the metric system is 102,072, and that the total of opponents is 1,161. On the basis of these figures advocates of the metric system claim that 98% of the American people favor the adoption of the system, while only 2% are against it. On the basis of these and similar estimates it is argued that the opponents of the metric system are a small organized circle who are blocking legislation and thwarting the will of the majority.

Included in the list of individuals favoring the metric system are such names as: J. W. Alexander, David P. Barrows, John Barrett, Alexander Graham Bell, William J. Bryan, Luther Burbank, Nicholas Murray Butler, Thomas A. Edison, Charles W. Eliot, Samuel Gompers, William C. Gorgas, John Hays Hammond, David Starr Jordan, Otto H. Kahn, Hudson Maxim, William G. McAdoo, J. J. Pershing, W. C. Redfield, Franklin D. Roosevelt, James Speyer, Henry van Dyke, Leonard Wood. Among the industrial concerns mentioned as already using the metric system in part or all of their manufacturing processes and favoring it, are included: Certainteed Products Corporation, The Crane Company, The Ford Motor Company, The Goodyear Tire & Rubber Company, Hammond Lumber Company, International Text Book Company, Simmons Company, United Light & Railway Company, The Waltham Watch Company. Statements from officials of these companies regarding the adoption of the metric system are often cited. Many other industrial concerns not yet using the metric system are also said to be in favor of it, and quotations similar to the following are commonly offered to show the drift of sentiment toward the metric system among American manufacturers.²

"Though the cotton industry as a whole is opposed to a compulsory change to the metric system, this opposition is due naturally to the disinclination to make the change. . . . A compulsory change to the metric system as a sole standard of weights and measures would be of ultimate good because of the greater simplicity in all calculations and records."³

¹ These had previously been distributed by the World Trade Club.

² All these statements are taken from replies to a questionnaire sent out by the National Industrial Conference Board, 1921.

³ Renfrew Manufacturing Company, Massachusetts.

"The industry is opposed to the compulsory adoption of the metric system but this is due to the want of study on the subject and an erroneous idea of the expense entailed in the change."¹

"I do believe that if the metric system were in general use in all industries it would be a very great benefit; would aid in promoting calculations of all kinds and in establishing standards. That its adoption would entail some confusion and a very considerable amount of expense cannot be denied. Any measure looking to its adoption should have these facts in mind and should provide for a considerable period over which the change could be gradually effected, thus reducing the expense of the change to the minimum."²

"We would be in favor of the metric system if it were generally adopted in this country. It has so many advantages over the English system that the expense would be justified."³

"Is it not generally recognized that the metric system is the simplest, soundest and most scientific system of weights and measures? This is the basis for my opinion that it will eventually be adopted by this and other countries that have not yet adopted it. If we are going to adopt it eventually why not do it as rapidly as possible? It will mean inconvenience and expense, as all big movements of this kind do. Personally, therefore, I line up on the progressive side of this question."⁴

"It would work a hardship at present but might be carried out through our schools and colleges using a dual system and then finally by adoption as a standard."⁵

"In our opinion it would be desirable ultimately, that is, looking fifty years into the future, if the whole world had one system, which then would be logically the metric system."⁶

"We use the metric system almost exclusively and we do not think there would be much difficulty in changing, but it would certainly be expensive."⁷

In connection with the claim that the demand for the metric system is growing also in Great Britain, replies to questionnaires sent out by the British Engineers' Association under the auspices of the Decimal Association of London are presented. Most of these, it is contended, were favorable to the compulsory adoption of the metric system.⁸ Since the war, metric advocates assert, the metric system has extended into many fields of industry and even into domestic trade in Great Britain⁹ which indicates, they say, that sentiment in favor of it is increasing there.

¹ A. P. Smith Manufacturing Company, manufacturer of general supplies and specialties for water works.

² Link Belt Company, manufacturing drive chains.

³ F. L. Smith & Company, foundry.

⁴ C. & G. Cooper Company, engine builders.

⁵ The Philadelphia Roll Machinery Company.

⁶ The Textile Machine Works.

⁷ The Perkins Manufacturing Corporation, manufacturing bakers' machinery.

⁸ Great Britain. "Evidence Before Committee on Commercial and Industrial Policy in 1917—Relative to Arguments For and Against the Adoption of the Metric System in the British Empire," evidence of Mr. Harry Allcock of the Decimal Association.

⁹ Cf. Note, Part III, Chapter XII, p. 151; also *Munsey's Magazine*, "The Metric System," April, 1916, p. 492.

English.

Advocates of the English system deny most emphatically that there is any demand worth serious consideration in favor of a change to the metric system in the United States. The deductions drawn from the list of names presented by the metric advocates, defenders of the English system insist, are wholly fallacious and misleading. It is pointed out that, on the one hand, this list was secured as the result of definite and insistent propaganda drives and that, if this is the best the pro-metrics can show, only 60,000 to 80,000 people in the United States out of a population of over 100 millions—less than one-tenth of one per cent of the whole—favor a change to the metric system. Such a demand, furthermore, could be accounted for by the scientific group in this country, which comprises about this proportion of the population and is known to advocate the metric system. On the other hand, English proponents continue, thousands upon thousands of people,¹ as well as prominent and important organizations, sent protests to Congress against compulsory metric legislation pending at the time the metric list was prepared, as a result of which protest, it is contended, the legislators came to realize the overwhelming opposition to such legislation and abandoned it.

English proponents maintain insistently that the propaganda in favor of the metric system has emanated from one or two propaganda organizations working for the purpose, which have spread broadcast throughout the United States literature of an essentially misleading character, and have induced individuals and organizations to send petitions favoring their cause in an effort to influence legislation. Such expressions favorable to the metric system, it is contended, have been secured largely, if not entirely, from those having no financial interests involved and nothing to lose by a change, while the fact that manufacturers and industrial interests having much at stake are strongly opposed to any change has not been mentioned.² In this connection it is pointed out that the prominent individuals most frequently quoted as favoring the metric cause are not industrialists and business men but such professional men as teachers, doctors, inventors, and others who are either interested chiefly in the scientific aspects of the question or have nothing of material value at stake or have espoused the cause

¹ Results of post card campaign carried on by the *American Machinist*, at the time the World Trade Club was preparing its list of those favoring a change.

² Dale, Samuel S. "Uniformity or Confusion of Weights and Measures," *Textiles*, February, 1918; also American Society of Mechanical Engineers. Report No. 972, Appendix 19, p. 710; see also "Bureaucratic Control of Weights and Measures," *Textiles*, March, 1920; "No Metric System for the Westinghouse," *Cotton*, October, 1920; "Shall We Lead or Follow?" *American Machinist*, 1920; "The World Trade Club and its Metric Propaganda," Reprint from *Textiles*, October, 1919; "The Metric System," Editorial, Rochester, New York *Herald*, April 8, 1920; "Mr. 'Z' of Boston," Editorial, *Chicago Post*, April 21, 1920, "Bureaucratic Control of Weights and Measuring Devices"; Samuel S. Dale, testimony on Committee on Mercantile Affairs, Massachusetts Legislature, February 17, 1920; cf. also United States. 58th Congress. Hearings before House Committee on Coinage, Weights and Measures, pp. 130-131.

as fallaciously represented by metric propagandists without giving due consideration to the practical side of the issue.¹ Mr. Walter Renton Ingalls, President of the Mining and Metallurgical Society of America,² sums up, it is claimed, the feeling of many engineers in this respect when he says: "I remember the time when I was in favor of its adoption (metric system) in the United States, and it was not until I studied the matter more carefully that I changed my mind."

To help create an impression that a general demand for the metric system exists in this country, it is contended that metric proponents frequently misrepresent and distort the opinions of associations, firms and individuals on the question.³ This, it is claimed, has resulted in a misunderstanding on the part of many who have been led to give their support to metric propaganda. It is pointed out that frequently an improper interpretation is placed by metric advocates on the terms "adoption of the metric system." American exporting firms when asked if they are using the metric system in any of their transactions have, upon replying in the affirmative, been listed as having "adopted" the system. Subsequent investigation has shown that their "adoption" meant simply the use of metric equivalents in connection with articles shipped to certain foreign countries. That many persons have been led to lend their support to the movement for a change to the metric system through ignorance of the situation and through failure to make a close examination of the question is strongly emphasized by English proponents. The following statement by Mr. Samuel S. Dale⁴ is cited in this connection:

The greatest danger to our established standards lies in popular ignorance. For years (thirty-five to my knowledge) the minds of children have been trained to believe in it (the metric system) as the only scientific system certain to become universal. Children leave school imbued with the metric fallacy. Why?—"Because my teacher says so." Editors of newspapers knowing practically nothing about the subject have aped the schools and colleges, taught the fallacy and increased the ignorance. In the encouragement of the popular ignorance lies the chief danger to our established standards. The remedy is in furthering discussion, and if any legislation is required, let Congress pass a law providing that John Quincy Adams' report of his investigations, begun in 1817, with an inclination in favor of the metric system, and finished in 1821, shall be printed at public expense; that a copy be placed in every public library in the United States; that it shall be kept constantly in stock for free distribution to the public; that every President, Senator and Congressman shall receive a copy with a recommendation that it be read before passing

¹ United States. 58th Congress. Hearings before House Committee on Coinage, Weights and Measures, pp. 130, 131.

² Halsey, F. A., and Dale S., "The Metric Fallacy," p. 167.

³ American Institute of Weights and Measures. Pamphlet, "A Recent Bit of Metric History." Dale, Samuel S., Letter, *St. Louis Post-Dispatch*, May 9, 1920; Dale, Samuel S., Letter, *Boston Evening Record*, January 13, 1919.

⁴ Discussion of paper by Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, pp. 918-19.

upon any bill affecting the weights and measures of the United States. That alone would make compulsory legislation forever impossible.

Practically all of the real sentiment in favor of a change, English proponents repeat, comes from teachers, scientists, some engineers and from a few manufacturers making refined instruments or other articles requiring a minuteness of measurement. However, even in these extremely small groups, it is pointed out, the sentiment is by no means uniformly in favor of a change, as is well indicated by the following quotations from two prominent educators, who say also that men of chiefly theoretical and laboratory experience often fail to see the practical issues involved in a question of changing to the metric system—practical issues which the manufacturers and business men of America would have to face.

"To representatives of educational associations and institutions who may have been led into an indorsement of the metric program, I would say that while naturally appealing to the workers in the laboratory, as I am in a position to appreciate, I feel sure that to make a metric law compulsory would be a great misfortune to this country."¹

"There is, I believe, a mistake in feeling that college officials and professors can be expected to favor the metric system and urge its adoption in this country to the exclusion of our established system of weights and measures. Such a feeling may exist among those who have not had practical manufacturing experience, but on the part of professors of mechanical engineering and those who are familiar with the needs of our factories, I believe there is a strong sentiment against a change. Further, I feel that it is distinctly hurtful to instill into the minds of college students ideas favoring a change in our basic standards which later experience in practical work makes it necessary to revise."²

The first of these quotations is by Dr. Alexander C. Humphreys, President of the Stevens Institute of Technology, and the second by L. P. Breckenridge, Professor of Mechanical Engineering, Yale University. Dean William Kent, Professor of Mechanical Engineering, Syracuse University, who sees the practical side of the question, expresses himself as follows:³

Even if the metric system were far superior to the English system, which it is not, and even if it were best to enforce it by compulsory legislation, which it is not, the enormous cost of introducing it, the vast trouble and confusion it would cause during the transition period for at least two generations, the abandonment of our mechanical standards upon which are based the present system of interchangeability of parts of manufactured articles, the making worthless of the greater portion of our technical literature, make the price too great to pay for any advantage real or supposed of the metric system.

¹ *American Machinist*, "Colleges and the Metric System," July 29, 1920, p. 242.

² *American Machinist*, "A Professor of Mechanical Engineering Writes on the Metric System," August 12, 1920, p. 338.

³ Halsey, F. A., and Dale, S. "The Metric Fallacy," p. 168.

The three quotations just given are from members of the teaching profession, but these men are likewise engineers. On the whole, English proponents contend, the engineering profession is opposed to a change to the metric system in the United States, relatively few engineers favoring it.¹ The most recent action of an American engineering body was that taken in the spring of 1920 in the form of a referendum vote conducted through *Automobile Topics*. This referendum showed that out of 967 votes cast 717 were opposed to the compulsory adoption of the metric system in this country while 250 favored it. In answer to the question as to preference for personal use, 295 expressed preference for the metric system, while 546 preferred the present system. For scientific reasons 410 favored the metric system and 364 were opposed. There was a decisive number of the 967 against compulsory legislation, even though 659 indicated that they had used the metric system to some extent.² The Engineers' Society of Western New York³ passed a resolution, in December, 1902, stating that the passage of any bill making the metric system compulsory in this country would be considered premature and that such action should not be taken without full and free discussion throughout the country. Similar expressions of the Aeronautic Division, S.A.E.,⁴ of the American Railway Engineering Association, and of other engineering bodies are cited by English advocates. It has been pointed out that the American Society of Mechanical Engineers is opposed to a compulsory change. It is also contended by English advocates that if a referendum were taken to-day among members of the American Society of Mechanical Engineers,⁵ the American Institute of Electrical Engineers, and the American Society of Civil Engineers, the vote would be most decidedly in the negative.

In the light of the evidence, English proponents reiterate, it is obvious that metric propagandists have simply been exploiting, as representative of all groups and of the country as a whole, a limited sentiment in favor of a change, expressed by an extremely small group of professional men and a few others. As a matter of fact, they continue, the relatively large fields of agriculture, mining, transportation and retail trade, which fields it is claimed have not yet had occasion to express themselves but would undoubtedly be opposed to a change, have been left entirely out of the metric

¹ Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, p. 923.

² American Institute of Weights and Measures. Pamphlet, "Thumbs down on the Metric System."

³ American Society of Mechanical Engineers. Report No. 972, Appendix XV, p. 705.

⁴ American Institute of Weights and Measures. Quarterly Bulletin, July 1, 1920, Extracts from Anti-Metric Resolutions.

⁵ In Vol. 24, p. 856, of the "Proceedings of the American Society of Mechanical Engineers," will be found the result of a referendum showing that the Society in 1903 registered a 4 to 1 opposition to the Metric Bill then in Congress. See also Vol. 24, p. 69, and Vol. 2, p. 9.

account, and the fact that the very important field of manufacturing has placed itself time and again on record as most decidedly opposed to a change has likewise been given no consideration.

In confirmation of the opposition to the metric system among manufacturers and business men generally, English proponents point to testimony similar to that elicited by the questionnaire of the National Industrial Conference Board to representative associations of manufacturers and through these associations to individual manufacturers, the results of which have been taken up in Chapter VIII in Part II. These results show that such industries as the textile, metal and machinery, food products, lumber, paper and printing, automobile, railway car, shipbuilding and other American industries are most decidedly opposed to a change.¹ The following quotations are representative statements cited to show the opposition of various manufacturers and associations to the compulsory adoption of the metric system.

"Our industry emphatically opposes any changes in our present system of weights and measures on the broad grounds that it would result in no direct or practical benefit to either manufacturer or purchaser."²

"We believe our industry as a whole is absolutely against any change to the metric system as being of any value whatever to the industry."³

"We do not approve of the metric system whether in the foundry or in the rest of the plant."⁴

"The metric system is not used in the hydraulic industry and there is no desire for its use; in fact, the industry is opposed to its compulsory adoption."⁵

"It is absolutely inadvisable to adopt the metric system as a standard and we are sure that if you will take this matter up with other manufacturers . . . you will find they will be unanimous in their contention that the metric system should not be adopted."⁶

"The industry does not favor a change to the metric system. In all of my experiences and discussion on this subject with the trade, I have found the same opinion, namely, that we should not change to the metric system on account of the confusion and lost motion resulting in changing our processes, equipment and the education of men and the undoubted slow-up during such a period of change, and the expense of it."⁷

"We believe that an international standard should be adopted but that it should be the English and not the metric, as a great preponderance of goods manufactured today is made in countries using the English system."⁸

¹ Cf. p. 100.

² Gurney Elevator Company, manufacturer of electric elevators, Honesdale, Pa.

³ La Crosse Plow Company, La Crosse, Wis.

⁴ Driver-Harris Company, foundry and wire manufacturer, Harrison, N. J., statement of the Vice-President.

⁵ The Hydraulic Society, New York City.

⁶ Benjamin Eastwood Company, manufacturer of textile machinery, Paterson, N. J.

⁷ Midwest Engine Company, Indianapolis, Ind.

⁸ Pratt & Cady Company, Inc., manufacturers of valves, hydrants, steam traps, etc., Hartford, Conn.

"Our industry does not demand a change and in fact opposes the metric system because of the difficulty of applying the same to physical construction."¹

Opinions and expressions along similar lines appear also in resolutions by various manufacturing and other associations.² The following organizations, it is pointed out, have expressed decided opposition:

National Association of Manufacturers.
National Metal Trades Association.
American Boiler Manufacturers' Association.
National Automobile Chamber of Commerce.
The Rubber Association of America.
The Motor and Accessory Manufacturers' Association.
The Manufacturers of Worcester, Mass.
The Manufacturers' Association of Erie, Pa.
The Michigan Manufacturers' Association.
The Ohio Manufacturers' Association.
The Associated Industries of Massachusetts.
National Implement and Vehicle Association.
The United States Chamber of Commerce.³

In the resolutions adopted by these various organizations appear such expressions as the following:

"We are opposed to any change in our present system of measurement."

"We express ourselves as strongly opposed to any legislation tending to supplant our established weights and measures by the enforced use of the metric system."

"We express our opposition to the proposed compulsory metric legislation."

"We record our opposition to the compulsory adoption of the metric system."

"It is unwise to make any change in our present system of weights and measures."

"Opposed to any steps looking toward any change in the system of weights and measures."

"This association is opposed to the substitution of the metric system of weights and measures for the present system."

"We stand ready to assist in defeating unwise legislation for the adoption of the metric system."

"We are unalterably opposed to any legislation proposing to compel the use of the metric system."

"Absolutely and positively opposed to the proposed metric system."

"We oppose the compulsory adoption of the metric system as economically unsound and inimical to the best interest of the country."

¹ Niles, Bement, Pond Company, Philadelphia, Pa.

² Cf. Monthly and Quarterly Bulletins of the American Institute of Weights and Measures, Extracts of Anti-Metric Resolutions. Cf. also, Halsey, F. A., and Dale, S. "The Metric Fallacy," pp. 153-190; and American Society of Mechanical Engineers. Report 972, Appendix VII, pp. 687-90 and Appendix XII, pp. 697-700; Cf. also American Society of Mechanical Engineers. Report No. 972, Appendix VII, pp. 687-690.

³ Including such subsidiary organizations as the Pittsburgh, Hartford, St. Louis and Trenton Chambers of Commerce.

"We disapprove the adoption of the metric system of weights and measures."

"We unanimously disapprove the adoption of the metric system."

"We are decidedly and unanimously opposed to the adoption of the metric system."

"Opposed to the compulsory establishment of the metric system."

Furthermore, English advocates maintain, evidence shows that what is true of the extent and character of the demand for the metric system in the United States is true also in Great Britain, where the situation is parallel. In support of this contention they refer to the reports of the Committees on Engineering Trades, Shipbuilding, etc., appointed in Great Britain to consider questions bearing on after-war trade, and to the evidence in hearings on proposed metric legislation before the British Parliamentary Committee on Commercial and Industrial Policy in 1917.¹

To sum up, English advocates deny that there is any demand worthy of serious consideration in favor of a change to the metric system in this country and point out that what little demand exists comes from teachers, scientists and a few others representing in all an extremely small group, not more than one-tenth of one per cent of the whole population—and that even this group is divided. Metric proponents, they say, have simply been exploiting a limited sentiment to make it appear that a strong demand for a change exists, have left the large and important fields of agriculture, mining, transportation, and trade entirely out of consideration, and have ignored the extremely important fact that manufacturers and business men generally are strongly opposed to a change. In view of the further fact that the metric propaganda has been of an exceedingly misleading character, tending to prejudice many people, and in view of the apparent ignorance on the part of a large portion of the public with respect to important considerations involved in the proposed change in systems in this country, proponents of the English system suggest, in conclusion, that no steps be taken regarding the compulsory adoption of the metric system until the people have been enabled to understand fully the bearings of the question.² When such bearings are fully understood, it is contended, it will be evident not only that there is no demand worthy of serious consideration in favor of a change and that there is a very strong opposition among American manufacturers and business men, but also that the public as a whole is definitely against a step which it feels would entail tremendous confusion and expense and carry with it no benefit.

¹ See article "Shipping Industry Against Metric Plan," *New York Journal of Commerce*, May 23, 1918; also Minutes of Evidence before Committee mentioned (multigraphed copy).

² Towne, Henry R., "Adoption of Metric System Would do Untold Damage," *Industrial Management*, June, 1920.

CHAPTER XV

COMPARISON OF THE METRIC AND ENGLISH AS UNIVERSAL SYSTEMS

The four preceding chapters deal with the leading special arguments about which the question of the adoption of the metric system in the United States revolves. Metric proponents, however, often rest their case on more general grounds, using an argument which practically sums up all others and at the same time presents the whole question in its broadest aspects. This argument bears upon the desirability of international uniformity in weights and measures.

The argument in general runs as follows: An international system of weights and measures for all uses is today an absolute necessity. Owing to the war the great nations have become so interdependent that in order to settle their financial and other problems there must be the greatest possible standardization, the freest possible commerce and the utmost simplification of business practice and trade relations. For the United States the home market will no longer suffice, while the vast sums which Europe owes to America must be paid in large measure with commodities, crude and manufactured.¹ Any means of facilitating trade is therefore of paramount importance. The world-wide acceptance of the metric system would not only promote commercial intercourse, but would be an agency of great value in fostering international peace.

Such general arguments, however, can be used in favor of any system that has a chance of becoming universal. Where metric proponents use these arguments, the advocates of the English system answer that they apply as well to their system, and that while world uniformity in weights and measures is admittedly desirable, the adoption of the metric system throughout the world is not the way to attain it. The possibility of achieving international uniformity of weights and measures on the basis of the English system, they contend, is no less than that of attaining it through wider use of the metric standards.

¹ Wade, Herbert T., "The Metric System and International Standardization." A paper presented at the Annual Meeting of the Metric Association, Pittsburgh, December 28-29, 1917, p. 6.

This chapter, therefore, will concern itself with the issues surrounding the question: Has the metric system, generally speaking, a better chance than the English of becoming the universal standard?

In putting forth the metric system as the most likely and the best adapted to become the universal system, metric proponents maintain specifically: (1) that, by and large, it is used more generally the world over than the English system and therefore stands a greater chance of becoming universal; (2) that the advantages and use of the metric system in special fields warrants its extension to all fields; and (3) that its chances of adoption are increasing annually in Great Britain and the United States, the two important countries remaining outside of the metric fold.

IS THE METRIC SYSTEM USED BY AND LARGE MORE GENERALLY
THAN THE ENGLISH SYSTEM AND HAS IT OTHER GREATER
CLAIMS TO BECOMING THE UNIVERSAL SYSTEM?

Metric

Metric proponents contend that the extensive use of their system, as measured by geographical distribution, indicates that it has a greater possibility of becoming universal and should, therefore, be extended to the whole world. It is pointed out that the metric system is in predominant use in 37 countries as against 12 in which the English system is in predominant use, that many additional countries, other than the 37 predominantly metric, have made the system compulsory for official and other limited uses, and that practically all countries of the world have made it a legally permissive system. Metric proponents observe that besides the solid alignment of continental Europe, Latin America is preëminently metric in that few Latin-American countries have not made the system compulsory for at least official uses and that it is the only system generally accepted by trades people and in the commercial life of that part of the world. Among "other countries" metric advocates also claim China and Japan, contending that China is in the process of adopting the system as the only standard,¹ and pointing to the fact that Japan has recently passed a law making it the exclusive system after twenty years. The following quotation from Director Stratton of the Bureau of Standards sums up the metric position in this respect:

The extent to which the metric system is used in foreign countries is not realized even by well-informed manufacturers. . . . The significance of this status is enhanced by the fact that China, a country of 400,000,000 people, is now in the process of adopting

¹ See p. 155 of present report. Also Stratton, Samuel W., Director of Bureau of Standards. "Metric System in Export Trade," January 6, 1916, p. 15; and Annual Report of the American Metric Association, 1919, Section 30.

the metric system. . . . With the metric system adopted in Europe, Latin America and China, our isolation with respect to units of weight and measure becomes steadily more complete. . . . It is therefore a most serious question whether we can afford to continue a system out of harmony with the rest of the world.¹

In short, it is maintained by advocates of the metric system that the United States, Canada, Great Britain, Russia, and their dependencies and protectorates are the only civilized nations outside of the metric fold,² and that even in these countries sentiment is swinging decidedly in favor of the metric system.³ These facts, it is finally contended, indicate that the metric system has already gained such a foothold that it cannot possibly be displaced; that it is bound in time to envelop the rest of the world; that it is now the only invariable international system; that its universal adoption in science and its extension to allied arts is fast bringing a knowledge of the system closer to the masses of the people; and that, everything considered, the metric system is the only one that has any considerable chance of becoming the universal system and should, therefore, be established as the world's standard.⁴

English.

English proponents, on the other hand, maintain that more people the world over use the English system than the metric, that it has been extended to all parts of the world and is used extensively even in countries nominally metric, and that, generally speaking, there is no reason why the English system should not be considered to have as great a possibility, if not a greater one, of becoming established as the world's standard.

Advocates of the English system contend that a comparison of the general use of the two systems, either by the number of governmental divisions having compulsory metric laws or by total populations of countries in which the metric system is used to a limited extent, is not a fair and practical basis of comparison, and argue that the only sound basis is the number of people actually using the one system or the other. They point out that the population of the 12 English countries is practically as great as that of the 37 metric countries, that in the 12 English countries the English system is used almost exclusively while in many of the 37 so-called metric countries other units of weight and measure, including the English, are often used as extensively as

¹ Stratton, Samuel W., Director of the Bureau of Standards, "The Metric System in Export Trade," Report to the International High Commission, January 6, 1916, Senate Document No. 241, 64th Congress, 1st Session, p. 15.

² Evidence before Committee on Commercial and Industrial Policy Relative to Arguments for and against the Adoption of the Metric System in the British Empire; Gregory, R. A., *The Decimal Educator*, June, 1920, p. 258; World Trade Club, Pamphlet, "Meter-Liter-Gram in World Trade and World War," pp. 5, 8 and 9; *Bulletin of the Pan-American Union*, "Exporting to Latin America," February, March and April, 1919, p. 145; Stratton, Samuel W., Director of the Bureau of Standards, "Metric System in Export Trade," January 6, 1916, p. 15; Comment on this Pamphlet by H. R. Towne, *American Machinist*, May 11, 1916.

³ See p. 207.

⁴ American Society of Mechanical Engineers. Report No. 972, Section I, p. 632.

the metric, and that also in countries, such as China and Japan, in which neither the English nor the metric system predominates the English system is used to a marked degree.¹

The importance of the use of the English system in "other countries" is emphasized by English advocates in view of the fact that the commerce of Great Britain and the United States with such countries has become extensive.² These "other countries," they point out, have a population of over 800,000,000, or considerably more than the metric and English groups combined; and many products intimately bound up with English units are constantly being exported to these countries from English-speaking nations, which situation is likewise true of many products exported to so-called metric countries; so that, everything considered, it is unquestionably true that the English system is used more extensively the world over than the metric. The following statement aptly summarizes the position of the English proponents on this point:

The sum total of advantages that might result from inaugurating any different system at the present time cannot be estimated by considering merely the number of governments which may not only have adopted it but rendered its use compulsory, or the number of countries in which the system may be nominally operative.

Whatever system may be agreed upon for universal adoption, the nations engaged in manufacture will be the larger users of the system. From a study of available statistics it is very probable that the number of persons in the United States, England, Germany and possibly France, who have adopted the English system is greater than the number of persons using the metric system in all countries combined. If this be so, assuming that a universal system should be adopted, a change from the French to the English will be much cheaper than a change from the English to the French, wherever the two systems are used.

While the number of countries in which the metric system has been adopted is much larger than the number employing the English system, the total of firms and individuals constantly using the metric system, and the value of the property concerned, shrink to small proportions when compared with the number of people engaged in industries using the English system and the assets they represent.³

Other factors also, it is maintained, such as the colonizing power of the English speaking races, the greater adaptability of English units to the work of the world, and the world-wide influence of the English language, demonstrate the value of the English system as a universal standard. It is stated that:

Measured either by industry or by commerce, the English units of measurement are in use to-day at least as extensively, and prob-

¹ Cf. Part I, Chapter 3, pp. 30, 32.

² See p. 108.

³ American Society Mechanical Engineers. Report No. 972, Appendix XIV, quoted from an editorial in *The Engineer*, Cleveland, Ohio, January 15, 1903, p. 702.

ably much more so, than those of the metric system. Measured by colonizing and assimilating power, the Anglo-Saxon race, which uses the pound, gallon, and foot as its standards of measurement, far outranks all the countries which use as their standards the kilogram, liter, and meter, combined. To the former already belongs the premiership in trade, in influence, and in control of the undeveloped and backward races of the world, having a combined population of over 600,000,000, not counting any of the so-called "Latin" countries, Russia, or the subordinate States of European powers.¹

It is also pointed out that "while neither of the two systems (metric and English) is perfect, the English is better adapted to the work of the world than is the metric. Its identity with other natural systems of weights and measures is so great as to make it the only feasible basis for the unification of the world's weights and measures."²

The relationship between the old Spanish, French and the English foot and inch has an important bearing here.³

Finally, it is contended that the English language is more likely than any other to become the universal language of commerce, the one language that every business man will have to learn. The English system of weights and measures being an indestructible part of the English language, English proponents continue, there is no more reason to suppose that the English speaking peoples are more likely to favor the metric system in place of the English than they would be willing to adopt the French language as a substitute for their own.⁴ An excerpt from a press despatch from Berlin, Germany, dated August 30, 1920, appearing in the *New York Sun* of September 2, 1920, is quoted in this connection:

English is favored in Germany as the international language that, it is admitted, will be almost a necessity for use in world communication when wireless telegraphy and wireless telephony have been made thoroughly practical.

Graf Arco, Germany's wireless authority, in an interview says that most of the trouble in complete interchange of ideas in the future may be found in the present use of so many languages.

"While I am an enthusiastic Esperantist," said Arco, "I believe a popular vote would elect the English tongue to be used generally in the transactions of business and transmission of news, because it is now spoken by the largest groups of people on the globe."

This statement, English exponents point out, is in conformity with M. Clemenceau's answer to the challenge of the French Chamber of Deputies as to why he allowed the English language to be used as the official language at the Peace Conference: "It is not our fault," he said, "that two-thirds of the civilized world speaks the English language." These facts, English advocates conclude, together with others of a similar nature, indicate that anything ap-

¹ Towne, H. R., "Our Present Weights and Measures and the Metric System," "Proceedings of American Society Mechanical Engineers," 1906, Section 53, p. 860.

² Dale, Samuel S., "Our Present Weights and Measures," *Textiles*, Jan., 1919.

³ Cf. Part I, Chapter I, and Part III, Chapter XI, also Dale, Samuel S., "Pan-American Weights and Measures," *Textiles*, Nov., 1920.

⁴ American Society of Mechanical Engineers. Report No. 972, p. 678.

proaching uniformity and universality in weights and measures is practicable only through the English system.¹ This sentiment is summarized as follows:

World uniformity can be attained only when the small minority abandons the metric system and conforms to the growing dominance of the English language and the system of weights and measures which is intimately interwoven with it, a language and a system which have gained their eminence through natural processes and not (through) uneconomic theories of professional propagandists.²

DO THE ADVANTAGES AND USE OF THE METRIC SYSTEM IN CERTAIN SPECIAL FIELDS WARRANT ITS EXTENSION TO ALL FIELDS?

Metric

Metric advocates contend that the preponderant use of the metric system and its adaptability to science, medicine, chemistry, engineering, fine instrument making, foreign trade, as pointed out in their arguments in Chapter XII, justifies its extension to manufacturing, retail trade, and all other fields.

This, they say, is particularly true as regards science and industry because of the increasingly close connection of the work of scientists and engineers with the field of industry. It is contended that in the past there has been great loss in not having the results of science more quickly available for industrial use. In the words of Dr. Stratton of the Bureau of Standards:

The relation between science and industry will become closer and result in the quicker application of new facts discovered by science. The result of lack of such an intimate relation has been seriously to retard industrial progress. It is a striking fact that the industrial utilization of scientific discoveries made in the laboratory has sometimes taken decades to accomplish. This was true of the gas light, the incandescent light, the arc light, the dynamo, wireless telegraphy, etc.³

An industrial product, it is held, must be adapted to the needs of the consumer, and the markets of the world will be completely opened if these needs are standardized according to the metric system.⁴ It is claimed that "as efficiency in all fields of activity is a ratio between the actual and the ideal, so in determining a standard we must aim as close as possible to the ideal,"⁵ and

¹ American Institute of Weights and Measures. Pamphlet, "The Tendency Toward World Uniformity," p. 26.

² *Idem.*, p. 26.

³ Stratton, Samuel W., Director of Bureau of Standards, "Metric System in Export Trade," Report to the International High Commission, Senate Document No. 241, 64th Congress, 1st Session, January 6, 1916, p. 16.

⁴ Wade, Herbert T., "The Metric System and International Standardization," A paper presented at the Annual Meeting of the Metric Association, Pittsburgh, December 28-29, 1917, p. 6.

⁵ *Idem.*, p. 5.

that "in such a case, whatever the material or article may be, the aim at the very outset should be to secure an international and ideal standard, in which the best technical and commercial knowledge of the special art or industry concerned should unite to secure the desired end."¹ Pro-metrics maintain that their system is the desired ideal.²

The following quotation is typical of their contentions in this respect:

The metric system is now the standard for chemists, physicists, and scientists all over the world and there is no valid evidence to show that a system of weights and measures which scientists find most convenient would not be equally so for all other users.³

English

English proponents deny the justification of such contentions as the preceding. While admitting that the metric system has certain advantages in scientific pursuits, they deny that it is of superior value and in more general use in engineering and foreign trade. They repeat that the English system is universally used in many fields, such as in the manufacture of machinery, cotton, rubber, lumber, in navigation, etc., to which it is much better adapted than the metric system, and that in the United States the number of people involved in the use of the English system in specialized fields to which it is applicable and in extensive use far exceeds the mere handful that use the metric system in pure science and related pursuits.⁴

English proponents refer to such arguments as they have advanced in Chapter XII relating to the fields of agriculture, mining and transportation, and especially to the manufacturing fields and domestic trade. These discussions, they assert, demonstrate that there is little demand for metric units in specialized fields, and that the adaptability of the English system to such fields, when the number of people affected and the value of the products are considered, not only justifies the retention of the English system in the United States, but also that such extensive use gives the English system a much greater claim than the metric system has to be extended to all fields of activity.⁵

Such comparisons as those made in Part II between the importance of the manufacturing field, as measured by the total number of people and the value of products involved, and the importance of the fields of science and engineering, medicine and fine instrument making, are pointed to, to substantiate English claims, viz.,

¹ *Idem*.

² Cf. Part III, Chapter XI—"Intrinsic Merits of Metric and English Systems."

³ American Society of Mechanical Engineers. Report No. 972, Section 7, p. 636.

⁴ See pp. 118-119.

⁵ Cf. English arguments, pp. 143-160 and 192-198.

that in 1910 those engaged in science and engineering, medicine and pharmacy and in the manufacture of fine instruments comprised only about one-half million people out of about 38 million productive workers, or one per cent of the whole,¹ and the number of users of the metric system is even smaller since the sentiment in favor of the metric system is little shared by the engineering professions. On the other hand, it is emphasized that over 10½ million people, or about 28% of the total productive workers, were involved in manufacturing and construction in 1910, while the total value of products manufactured in 1914 was over 24 billion dollars, or over 64% of the total production of the United States for that year.²

The manufacturing field, English proponents continue, is unquestionably the most important field of industry in the United States. Furthermore, from the standpoint of the nature, fabrication and sale of the products involved, a totally different situation obtains in it from that existing in the purely scientific fields. The distinction between the measuring of a thing already existing and the making of something to measure is emphasised and attention is again called to the fact that manufacturing is the field in which things are made to measure, and whatever measures are used are intimately tied up with the resultant product.³ In science, the primary consideration is a unit of measure that will afford relatively accurate measurements and which can be readily handled from the standpoint of computation. In the making of a commodity to measure the important consideration, English proponents point out, is that the product be made of convenient size or of handy weight. In this respect, they maintain, as pointed out in the chapter on intrinsic merits,⁴ the English units are far superior and better adapted to manufacturing than the metric units. There is absolutely no warrant, therefore, English proponents conclude, for foisting a system used by a possible 1% of the productive population upon 28% of the people, engaged in a field in which the English system is thoroughly established and has proven of superior merit.

With respect to foreign trade, proponents of the English system see no reason why this field should prefer any one system over another so long as uniformity is secured. The trade of the world, they say, is certainly not carried on more in the metric system than it is in the English. As a matter of fact, the English system predominates. They maintain also that the metric system has been favored by legislation everywhere; that such use as it has in international commerce is due to this fact; that in spite of such legislation, the international use of the English system has steadily

¹ Cf. Part II, Chapter 6, p. 65.

² Cf. Part II, Chapter 5, Table 1, p. 53.

³ See p. 153 and also p. 98.

⁴ See pp. 138-139.

grown; and that, were legislative support or interference withdrawn and the systems left to stand or fall on their own merits, the metric would substantially disappear from international commerce.

With respect to retail trade, English proponents assert that the greatest general use of weights and measures is probably in this field, affecting as it does the whole population. It was estimated by Herbert Spencer that the use of weights and measures in retail trade is fifty times as great as the rest of its uses together. If the question were put to a popular vote—whether a “perfect 36” should be changed to a perfect 91 centimeters, the results, they say, would be illuminating. If it be a question of present day use, it is contended that the English system stands far above the metric system and for the English speaking countries the metric system has hardly any place except in limited fields.

In short, English proponents point out, the preponderant use of English units in special fields, particularly in manufacturing and retail trade, is a much greater warrant that the English system should be made universal than that the metric system, predominant only in the very limited field of science, should be extended to include other fields.

ARE THE CHANCES OF ADOPTING THE METRIC SYSTEM INCREASING IN GREAT BRITAIN AND THE UNITED STATES?

Metric

Metric proponents contend finally that the use of the metric system and opinion in favor of it is steadily increasing in Great Britain and the United States, that there is a growing realization that the English system is crude and confusing and that the adoption of the metric system in these countries would eliminate this confusion and secure world uniformity.

The following quotation indicates the attitude of metric proponents on the first point:

It is almost certain that the metric system is annually gaining strength, both here and in Great Britain and the British Colonies. The evidence obtainable seems to point that way. The resolutions of technical and trade associations and the foothold it now has before legislative bodies indicate this; and it seems not improbable that Great Britain may anticipate us in the adoption of the system.¹

It is maintained again in this connection that the extensive use of the metric system in Great Britain and the United States in science, medicine, pharmacy, engineering, and allied fields is being rapidly extended to manufacturing and retail trade, and also to

¹ American Society of Mechanical Engineers. Report No. 972, pp. 652-654.

foreign trade.¹ It is contended that factories in the United States and Great Britain during the war turned out an enormous amount of war material manufactured to the metric scale and that as a result there are many thousands of workmen in these countries today who are as familiar with centimeters and grams as they were formerly familiar with inches and ounces.² These facts, it is asserted, indicate that there is a growing tendency in its favor in English speaking countries, and that the transition to the metric system could be easily made. With respect to the claim that people in the United States and Great Britain are realizing more and more that the English system is cumbersome and confusing, it is held that such discrepancies as are found in measures having more than one value, like the ounce, pound, ton, pint, and quart—which metric proponents claim vary in legal equivalents in different states and in Great Britain and the United States³—would be eliminated by the adoption of the metric system. Such discrepancies, metric advocates conclude, cannot exist in the metric system where all units of the same name have but one value.

English

Proponents of the English system repeat their denial, elaborated in the preceding chapter, that there is any demand worthy of serious consideration in favor of the metric system in Great Britain and the United States, and contend that, on the contrary, there is increasing indication that the English system, with slight modifications, is coming to be fully recognized as the ideal system.

In this respect the point is emphasized anew, that whatever increase in sentiment in favor of the metric system there is in the United States and Great Britain comes from the scientific field which represents less than one-half of 1 per cent of the total population of the United States⁴ and about the same percentage in Great Britain. Over and against this must be set, it is contended, the strong opposition to the metric system that has developed in the manufacturing and other fields in these countries, which opposition is decidedly on the increase. Other aspects of the English position on this point are brought out in the following quotation:

¹ Stratton, Samuel W., Director of the Bureau of Standards, "Metric System in Export Trade," Report to the International High Commission, *Senate Document No. 247, 64th Congress, 1st Session*, January 6, 1916, p. 7-16.

² Bulletin of the Pan-American Union, "The Metric Standard," January, 1917, p. 28.

³ World Trade Club. Pamphlet, "An Evening at the World Trade Club," Statement of Dr. Joseph V. Collins, p. 11; also Wells, W. C., *Scientific Monthly*, "The Metric System from the Pan-American Standpoint," March, 1917, p. 200; World Trade Club. Pamphlet, "Meter-Liter-Gram in World Trade and World War," p. 3. *Literary Digest*, "Juggling With Our Weights and Measures," May 29, 1920. Stratton, S. W., Director, Circular of the Bureau of Standards, No. 10, May 9, 1918; see also United States. 58th Congress. House Committee on Coinage, etc., Hearings, pp. 135-137, 141-144, 197-209; also Gould, B. A. Address on the Metric System of Weights and Measures before Commercial Club of Boston, Feb. 18, 1888, p. 4.

⁴ Cf. Part III, Chapter XIV, p. 192.

Against the growing strength of opinion as shown by resolutions, etc., in favor of the metric system we have to show the far greater growth of practice with the English system, due to the rapid growth of population, wealth and industrial pursuits in English-speaking nations, the building of railroads, shops, etc., the general tendency to standardization of sizes (based upon the inch) of articles of manufacture and the tools for making them; the spread of technical education, correspondence schools, etc., and the ever-increasing mass of technical literature based upon English standards.¹

Regarding the assertion that there is considerable confusion among the units of the English system and that people are increasingly realizing this, proponents of the English system insist that this is absolutely false, that as a matter of fact there is no ambiguity between dry and liquid measures and avoirdupois and troy weights, since these are used only with respect to certain well-defined classes of material known to every one, i.e., the troy pound and the apothecaries' pound are never used in commerce; the troy ounce is the unit used for weighing gold and silver, and the apothecaries' weight does not exist outside of the prescription department of drug stores. Furthermore, where the several states have passed statutes establishing certain seemingly arbitrary and irregular measures, advocates of the English system continue, these relate in the main to the measurement of agricultural products such as wheat, potatoes, apples, etc., and most of them consist in defining the *weight* per barrel or bushel or peck. Obviously, they say, these differences in weight are inherent in the nature of the merchandise to be measured, varying with its specific gravity, and have nothing to do with any system of weights, measures, or volume. What is needed with respect to merchandise and other products also, is a more thorough-going standardization of the practices employed, and this applies with even more force where the metric system is used than in English-speaking countries, since in the latter the process of standardization has proceeded much farther than in metric countries.

Metric assertions on this score, it is claimed, merely becloud the issue. The United States and Great Britain, English advocates argue, have a degree of uniformity of weights and measures unapproached by any metric country, not excluding France,² which uniformity would be destroyed by the adoption of the metric system. To prevent an obscuring of the issue it is urged that certain historical facts be kept in view, i.e., it should be realized that France devised and adopted the metric system primarily to obtain *domestic uniformity*; that Germany, likewise seeking domestic uniformity, adopted the metric system as a means toward this end;

¹ American Society of Mechanical Engineers. Report No. 972, p. 655.

² American Institute of Weights and Measures. Pamphlet, "Shall the Tail Wag the Dog?" Towne, Henry R. "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, p. 326.

that nearly all other countries that have adopted the metric system have either been contiguous to France or Germany or have been influenced by the affinity of the Latin races; that the United States now has, and always has had, domestic uniformity and also has international uniformity with populations at least equaling those of the so-called metric countries; and that the United States by adopting the metric system would lose this domestic uniformity and in its stead would acquire a dual system for the next two or three generations and for a much longer period of time as far as concerns land titles, structures and all enduring equipment, while at the same time she would lose the international uniformity she now enjoys with at least half of her foreign markets. Mr. Towne sums up the matter in the following words:

We now have absolute national uniformity, and, except as to measures of volume, international uniformity with the British Empire. No other nation in the world, save Great Britain, enjoys today such absolute uniformity as to weights and measures as the United States. We may change our scales, if we retain our present base units, without losing this national blessing, but if we change our units of weights and measures, we shall substitute, for a hundred years or longer, confusion in place of the absolute unity we now enjoy. Other countries have changed their system to secure uniformity; we now have uniformity, but would lose it if we should change our system. Let us make sure that the benefits to be secured by change would outweigh the difficulties and objections which any change of units implies, or else let us keep our present units.¹

Finally, English proponents maintain that there is an increasing feeling in the United States and Great Britain that the English system, with slight modifications, is a much more ideal system than the metric because of the intrinsic merits of the former, as pointed out in Chapter XI in this Part. It is claimed that a little simplification and a more extensive decimalization will make the superiority of the English system over the metric fully apparent. In this connection it is pointed out again that although the metric system has been legal in the United States since 1866 little progress has been made toward its general use. Had it possessed ideal qualities,² it is contended, it would long since have crowded out the English system, which, on the contrary, has successfully held its own and has enabled the United States and Great Britain, in spite of metric legislation, to become leaders in industry and trade.

In this connection it is pointed out that only recently a committee in Great Britain, appointed by the Conjoint Board of Scientific Societies, after a careful investigation recommended the retention of the English system, the further decimalization of its

¹ Towne, Henry R., "Our Present Weights and Measures and the Metric System," "Proceedings of the American Society of Mechanical Engineers," 1906, p. 870.

² Halsey, F. A., and Dale, S. "The Metric Fallacy," p. 86.

units, and the elimination of such units as have become obsolete and useless. Their recommendations, in part, are as follows:

That the British system of weights and measures be retained in general use in the United Kingdom; that no proposals for modification of these units with the object of improving their *interrelation* be entertained; and that *no new fundamental* unit be established.

In the matter of simplification of the British system, the Committee recommends:

MEASURES OF LENGTH—The abolition of the pole, furlong and league; the limitation of the link and chain to use in the determination of area.

MEASURES OF WEIGHT—The abolition of the grain, dram, stone, quarter, and hundred-weight of 112 pounds, and the complete abolition of Apothecaries' Weight.

MEASURES OF CAPACITY—The use of the gallon as the general standard, with the customary subdivision into quarts and pints for retail use, but not otherwise, the abolition of the peck, bushel, quarter, chaldron, and barrel, and the substitution of measure by weight.

MEASURES OF AREA—The abolition of the square rod or perch and the rood, all areas of land being in acres and decimals, or in square feet for small plots, and all other superficial measures being in square feet.¹

English proponents suggest in conclusion that a conference of Great Britain, the United States, and other countries be called to study carefully all natural systems of weights and measures with a view to a more complete standardization of the inch and the foot the world over and to draft legislation to be enacted, not only by Great Britain and the United States but by other countries, in the interest of simplifying the English system and legalizing it in various countries as a world standard along with, if not superseding, the metric system.

¹ Report of Metric Committee Appointed by the Conjoint Board of Scientific Societies of Great Britain, February, 1920, pp. 35 and 36.

CHAPTER XVI

SUMMARY OF METRIC CONTENTIONS AND ENGLISH ANSWERS

Metric

Following the order of the issues presented in the preceding chapters, advocates of a change to the metric system maintain:

- (1) That the metric system is intrinsically superior to the English, due, it is contended, to—
 - (a) The scientific character of the fundamental units of the meter, liter and gram, and the simplicity of the relationship between them;
 - (b) The simple decimal manner in which multiplication and division of units of the same measure proceeds, and which they claim
 1. Makes the metric system easier to work with and makes for simplicity in computations; and
 2. Avoids the present mixture of binary and decimal fractions in use in the English system.
 - (c) The smaller number of units in common use and the greater ease with which the names are learned and retained;
 - (d) The greater comprehensibility of the system as evidenced by the simplicity of structure indicated under "a," "b" and "c," and
 - (e) Its greater convenience, greater adaptability and greater comprehensiveness in filling the needs that a system of weights and measures is called upon to fill.
- (2) That the metric system is of superior advantage and in extensive use in special fields. They maintain
 - (a) That the metric system is of greater advantage and in extensive use in calculations, educational work, technical literature, etc.;
 - (b) That it is of superior value and in predominant use in scientific and related pursuits;
 - (c) That it is applicable and very frequently used in engineering activities;
 - (d) That the advantages and use of the metric system in scientific fields warrant a change to that system in agri-

culture, mining and transportation activities as well, because of the intrinsic merits of the metric system and because the increasingly close relation between the development of these fields and scientific research emphasizes the importance of using one system in all of them;

- (e) That the advantages and use of the metric system in manufacturing warrant a change in this field;
 - (f) That the metric system would be found advantageous in domestic trade; and
 - (g) That because of its wide use in the foreign trade of other countries, its adoption here would foster the trade of the United States.
- (3) That a change to the metric system in the United States would be eminently practicable. They contend
- (a) That the experience of other countries in suppressing older units shows that there would be no serious general difficulties involved in such a change through its relation to general popular customs and habits and to practices in the chief fields of activity, and that the people would adopt the new units easily and without confusion after a short period of transition, especially if the compulsory law were gradually applied and extended;
 - (b) That such a change would necessitate little altering or discarding of mechanical standards and equipment but would involve in the main only the applying of metric measurements to the units of our present standards, which would be preserved without change so long as it might be desirable or advantageous to do so;
 - (c) That the cost of a change has been greatly over-estimated and would involve only the translation and revision of literature and the replacing of present weights, measures and scales, and that the cost of such revision would be more than compensated for by savings resulting from the change.
- (4) That there is a strong and growing demand for a compulsory change in the United States. This is evidenced, it is maintained, by the general extent of the demand as seen in petitions to Congress signed by thousands of names, and by the character of the demand, representing as it does many varied interests, such as science, chemistry, invention, education, engineering, manufacturing, exporting, etc.
- (5) That the metric system, generally speaking, has a better chance than the English of becoming the universal system. They contend
- (a) That it is used by and large more generally than the English system;
 - (b) That the advantages and use of the metric system in certain fields warrant its extension to all fields; and
 - (c) That the sentiment in favor of a change to the metric system is growing in Great Britain and the United States.

English

Those opposed to a change from the English to the metric system in the United States deny most of the contentions of the metric advocates, and also on the other hand set forth certain claims of their own. They maintain:

- (1) That the English system is intrinsically superior to the metric.
 - (a) They deny that fundamental units of the metric system are absolutely scientific in character; and claim that the practical and natural character of the fundamental units of the English system make the latter intrinsically superior to the metric, and also that there is little practical value in having measures of weight, length and capacity related to one another.
 - (b) They maintain that the binary and duodecimal manner in which multiplication and division of English units proceeds is of superior value. They claim
 1. That common fractions are easier to visualize and therefore to work with than decimals, and although decimals do lend themselves to calculations, common fractions are superior for general practical use; and
 2. That the English system is adapted equally to the use of both binary and decimal fractions, by reason of which it is able to meet a need in human nature for the use of binary and duodecimal relationships, which need cannot be filled by the metric system with its strictly decimal structure.
 - (c) They maintain that the common units of the English system are fewer in number and that their names, being of ancient origin and mostly monosyllabic, are more easily learned and retained than are those of the metric system.
 - (d) They deny that simplicity of structure is synonymous with easy comprehensibility and maintain that the English system is more comprehensible than the metric, in that its units fit every-day needs, are fewer in number, of handy sizes, brief in name, and are easily memorized and associated with every-day experience.
 - (e) They contend that the English system is more convenient, more adaptable and more comprehensive in filling the needs that a system of weights and measures is called upon to fill, because of its binary and duodecimal divisibility, the practical relationship of its units, its adaptability to the requirements of progress as seen in the dropping of obsolete units which had outlived their usefulness, and its use of both binary and decimal subdivisions.
- (2) They maintain that the metric system has no demonstrated advantages or extensive use in special fields, contending
 - (a) That the metric system is neither of greater advantage

nor in more extensive use than the English system in calculations, educational work, technical literature, etc.;

- (b) That, while admitting certain advantages and use of the metric system in science and in fine instrument making, the so-called absolute or "centimeter-gram-second" system rather than the metric system is the one employed in scientific work; and that the use of parts of the metric system in scientific work is not an indication of the advisability of adopting it generally, since the scientific field is small and its methods and products not fixed or standardized;
 - (c) That electrical engineers use a "mongrel system" and not the metric system; and that the English system is more applicable and more generally used, especially in the United States and Great Britain, in other engineering fields;
 - (d) That the metric system has no advantages over the English system in agriculture, mining and transportation, while the English system is thoroughly established in daily use in all these fields, and has been found adequate in filling the needs of the people, and that, furthermore, only confusion would result from a change;
 - (e) That the metric system offers no special advantages in manufacturing in general, while the whole manufacturing field in the United States has been built up in and around English units; that the English system is especially applicable to most industrial processes; that many industries the world over have been developed in this system and that it is used in many metric countries in the manufacture of special products;
 - (f) That the metric system is not better adapted to domestic trade than the English system, while the English system is thoroughly established and in daily use in retail trade, and that a change would require the changing of the habits of the entire buying public, which the experience of other countries has shown would be difficult; and
 - (g) That a compulsory change to the metric system would not be advantageous to the foreign trade of the United States, since that trade is already established and flourishing in the English system, and since at least half that trade is with non-metric countries.
- (3) They maintain that a compulsory change to the metric system in the United States would be extremely impracticable, asserting
- (a) That the experience of other countries shows that the change involves enormous disturbance to the every-day habits and customs of the whole buying and traveling population of a country and creates untold confusion in business practices and that the transition requires a long period, all of which difficulties would be intensified in the United States regardless of the character of the

compulsory legislation, because the English system is thoroughly established here;

- (b) That the adoption of the metric system would necessitate the immediate discarding of the established system of standards and the equipment embodying it and the abandonment of interchangeable parts, because it would be impossible to apply equivalent metric designations to old standards or to gradually replace old standards and equipment with new metric ones, and a protracted period of waste and confusion would have to be reckoned with in any case;
 - (c) That the cost of the change would be tremendous, in fact prohibitive, involving not merely translation and revision of literature but enormous and costly changes in material and equipment and slow and difficult reeducation of the people. To industry the material cost would average over \$200 per worker, plus the additional expense due to inefficiency, waste, and the carrying of a double stock of repair-parts over a long period of years.
- (4) They contend that there is no demand worthy of serious consideration for a change to the metric system in the United States, and that what little demand there is comes mainly from scientists, teachers, and associations formed for the purpose of spreading metric propaganda, while decided opposition comes from manufacturers, engineers and those involved in other large and practical fields, which fields are the ones that would suffer most through a change.
- (5) They maintain, finally, that the English system has as good, if not a better chance than the metric of becoming the universal system.
- (a) It is pointed out that the English system and not the metric is used by and large more generally, and has, therefore, the better chance of becoming established as the universal system.
 - (b) It is denied that the advantages and use of the metric system in certain fields warrant its extension to other fields; and it is maintained that the advantages and use of the English system in the larger and more important fields justify the retention of the English system in those fields and its use in all fields of activity.
 - (c) It is denied finally that the metric system is gaining strength in Great Britain and the United States, the fact of its insignificant adoption after having been permissive for 55 years being pointed to as conclusive evidence that the people in these countries do not want it. Furthermore, it is contended, on the contrary, that there is increasing indication that the English system, somewhat simplified and decimalized, as it can readily be to any desired extent, is rapidly coming to be fully recognized as the ideal system, destined for this reason ultimately to come into universal use.

APPENDIX
TABLES V TO VIII

APPENDIX

TABLE V

PRESENT NATIONAL STATUS OF METRIC, ENGLISH AND OTHER SYSTEMS OF WEIGHTS AND MEASURES

(A) *Metric System in Predominant Use*
(Arranged in Order of Date of Compulsory Adoption) *

Name of Country	Population 1920 ¹	Dates of Compulsory Legislation	Date Use Made Optional	Present Status Extent to Which Older Ethnic Systems Have Been Replaced ²
Belgium	7,650,000	1820 1855 1820	1816	Metric system almost universally employed.
Luxemburg	260,000 *		1816	Old weights and measures occasionally used but practically obsolete.
Netherlands	6,800,000	1820	1816	Occasional traces of older weights and measures. Other units than metric employed in shipping.
France	41,500,000	1840	1793	Metric practically universally used in France and most of its colonies. Old terms seldom found. English units used in some textile industries.
Spain	20,850,000	1853 1855 1892 1917 1857 (governmental use only)	1849	Metric system used almost universally. Although old measures are not legal they are still found in smaller towns.
Colombia	5,500,000		1853	Metric compulsory for official use only. Among educated people particularly, metric system has supplanted old units. Old measures still occasionally used in interior and among local dealers.
Portugal	6,000,000	1862 1872	1852	Officially, the metric system is in universal use. Old units still occasionally used among lower and agricultural classes, although forbidden in receipts or legal documents.

* For alphabetical arrangement, see pp. 16-27.

Mexico	15,500,000	1862 1865 1896	1862	Metric system in general use. Old weights and measures still used to small extent in rural districts and by small dealers. English units occasionally used.
Uruguay	1,400,000	1862 1894 1918	1862	Metric system has nearly supplanted all old units, including those of Spanish system. Old units seldom used.
Italy	36,750,000	1863	Varied in different sections from 1845-1870 1862	Old measures and weights still found occasionally in Southern Italy. In Northern Italy change to metric system is complete.
Brazil	30,500,000	1864 1874		Metric is official system. In general use by people at large. Old Brazilian system still occasionally used in the interior. English units are occasionally employed.
Chile	3,900,000	1865 1891	1848	Metric system now in general use. Old Spanish units used to small extent by the people, and the <i>quintal</i> in nitrate industry. English measures used in navigation.
Germany (including Danzig)	55,350,000 ⁴	1872	1870	Use of metric system complete and general. Old units seldom found. English units used in textile trade.

¹ Populations for the most part are taken from the "Statistical Abstract of the United States, 1920", Table 454, pp. 838-39, which gives the figures for 1920 or for the latest available date. The populations given for a few countries represent the estimates of the "Statesman's Year Book," 1920, and, where used, this source is noted.

² The following comments are for the most part generalizations and the experience of the individual countries is treated somewhat more in detail on pp. 18-27. It must be noted that English or others units are sometimes used in special trades, such as textiles, carpentry, land measurements, screw threads, etc., in metric countries. It must also be noted that the metric system is used in science, medicine, etc., almost exclusively in many "English" and "Other Countries." These exceptions are treated in detail in Part II of this report.

³ "Statesman's Year Book," 1920, population for 1916.

⁴ *Ibid.*, estimated population of the present Republic.

TABLE V—Continued
PRESENT NATIONAL STATUS OF METRIC, ENGLISH AND OTHER SYSTEMS OF WEIGHTS AND MEASURES
(A) Metric System in Predominant Use—Cont'd

Name of Country	Population 1920	Dates of Compulsory Legislation	Date Use Made Optional	Present Status Extent to Which Older Ethnic Systems Have Been Replaced
Austria	6,100,000	1876	1873	Old measures seldom found. The English sea mile and ship ton are used in navigation.
Hungary	12,000,000*	1876	1876	Metric system in general use. Old measures occasionally used in isolated districts.
Czecho-Slovakia	13,600,000	1876	1873	Metric system in general use, and has almost completely supplanted old units.
Monaco	23,000*	1876	1876	Metric system in general use.
Switzerland	3,850,000	1877 1887	1875	Metric system principally used. Old units still appear in country districts to small extent.
Norway	2,600,000	1879 (for govern- ment use) 1882 (for general use)	1879	Metric system used almost universally. Old units found only in fishing trades.
Argentina	8,300,000	1879 (for govern- ment use) 1887 (for general use)	1863	Metric system in general use. Old Spanish units used occasionally in special fields. English terms used in navigation.
Jugo-Slavia: Serbia Bosnia-Herzegovina ..	14,400,000*	1883 1912	1873 1878	Old Turkish weights and measures not fully sup- planted. Metric system generally used by the people.

Rumania	17,400,000	1884	1884	Metric system in general use. Turkish units still found occasionally.
Montenegro	437,000 ^a	1888	1888	Metric system used generally. The Turkish <i>oke</i> used occasionally by the people.
Sweden	5,800,000	1889	1879	Metric system almost universal. Old English <i>mil</i> (6 1/3 English miles) the only old unit in general use.
Bulgaria	5,500,000	1891	1888	Although a few old units are still found, metric system has nearly supplanted old Turkish units.
Finland	3,300,000	1892	1886	Metric system prevails. Old units seldom used.
Nicaragua	740,000	1893	1893	Metric system sole legal standard. Used in commerce except with the United States. Old Spanish units still used to some extent.
Tunis	2,000,000	1895	1895	Metric system has almost entirely supplanted old units. Corn still sold in <i>kaffis</i> and <i>ukibas</i> .
Paraguay	1,000,000	1899 (for official and legal use)	1899	Metric system sole legal standard and in general use. Other units including English and Spanish still used to small extent.
Philippines	10,600,000		about 1849	Metric system in general use. Old Spanish system still employed to small extent by natives of the interior. English units used to a small extent.
Congo (Belgian)	15,000,000	1910	1910	Metric system is in general use.

^a *Ibid.*, estimated population of the present Hungary proper.

^b *Ibid.*, population for 1913.

^c *Ibid.*, estimate of present population.

^d *Ibid.*, population for 1917.

TABLE V—Continued

PRESENT NATIONAL STATUS OF METRIC, ENGLISH AND OTHER SYSTEMS OF WEIGHTS AND MEASURES

(A) *Metric System in Predominant Use*—Concluded

Name of Country	Population 1920	Dates of Compulsory Legislation	Date Use Made Optional	Extent to Which Older Ethnic Systems Have Been Replaced	Present Status
Denmark	2,950,000	1910 (for customs and public service) 1912 (for general use) 1912	1910	Metric system used in customs and in all public service and by the people generally. Some old units still used occasionally. Old land area standards permissible until 1925.	
Venezuela	2,850,000		1857	Metric system in general use. Old Spanish units seldom found, except among people in the interior. English units sometimes employed.	
Latvia	2,500,000 ^a	1919	1919	Metric system in general use. Old Russian measures permitted where necessary until 1926.	
Poland	30,100,000 ^a	1919	Introduced into different sections at different periods.	Old Russian units formerly used in Russian Poland are little used at the present time, having been gradually supplanted by the metric system. Metric system almost universal.	
Haiti	2,500,000	No specific date	Introduced during colonial period.	English system used to small extent, usually in commerce with the United States, but metric now in general use.	
Liechtenstein	11,000 ¹¹			Metric units in general use.	
Total population ...	395,521,000				

^a *Ibid.*, population for 1914.¹⁰ *Ibid.*, estimated population¹¹ *Ibid.*, population for 1912.

of present Polish Republic for 1910-11.

(B) *English System is Predominant Use*

Name of Country *	Population 1920	Date Metric System Made Optional	Present Status Extent to Which Metric System is in Use
Porto Rico	1,300,000	about 1849 1902 ^a	While both systems are in general use, the English units are gradually supplanting the metric, due largely to influence of trade with United States. They are also supplanting the old Spanish units.
United Kingdom	46,100,000	1864 1897	Metric system seldom used except in scientific and research work, to a limited extent in foreign trade and in the electrical industry.
United States	106,750,000	1866	Metric system used in science and in a few modern technical processes; in electrical work; by the Coast and Geodetic Survey, in its official and triangulation work; in Army and Navy, and to a limited extent in manufacture and export trade. Use very limited.
San Domingo	1,000,000	1867 ^a 1913	English system in general use. Metric used only in municipal markets, customs and other governmental work. Spanish units used to a limited extent.
Canada	8,400,000	1871	Use of metric system very limited.
Russia	164,100,000 ¹⁴	1900	Metric system used in scientific work, in customs, in pharmacy and by medical department of army and navy.

* Arranged according to date metric system was first introduced. For alphabetical arrangement, see pp. 27-29 of present report.

^a Metric system made compulsory for nearly all uses by law of 1902. Law of 1913 established parts of the English and the metric system as standards on an equal basis.

¹⁴ Metric system was adopted as the sole legal standard in 1867 and use of other units was punishable by fine. This was reinforced by presidential proclamation in 1913. However, this has not been enforced and English units predominate. Spanish units are also used to a small extent.

¹⁵ "Statesman's Year Book," 1920; population of Russia for 1915, omitting Poland, Finland and Latvia.

TABLE V—Continued
PRESENT NATIONAL STATUS OF METRIC, ENGLISH AND OTHER SYSTEMS OF WEIGHTS AND MEASURES
(B) English System in Predominant Use—Cont'd

Name of Country	Population 1920	Date Metric System Made Optional	Present Status Extent to Which Metric System is in Use
New Zealand	1,200,000	....	Metric system never adopted by Government. General Assembly passed an act in 1908 vesting Governor with power to legalize system by Proclamation. This power never used. Metric system used only in science and research. Metric system seldom used except in science, and in automobile and electrical supply houses. Metric system used only in government chemical laboratory, where its use is compulsory, otherwise little used. English units generally used. Metric system seldom used. Metric system not used except by chemists. Metric system is seldom used.
Australia	5,150,000	....	
British Guiana	311,000 ¹⁸	....	
Straits Settlements	846,000 ¹⁸	....	
South Africa	6,900,000	....	
Liberia	1,500,000	....	
Total population.....	343,557,000		

¹⁸ *Ibid.*, estimated population for 1918.

¹⁹ *Ibid.*, estimated population.

(C) Other Countries

Name of Country *	Population 1920	What Systems in Use	Date Metric System Made Optional	Date Metric System Made Compulsory for Special Uses	Comment
Cuba	2,900,000	(a) Spanish Metric Spanish English	1849		Metric system used in all official work, in customs and also generally for liquid measurements. English units used in import trade with United States and Great Britain. Old Spanish units commonly used in native trade in the interior. Metric system is legal standard but is used only officially. Metric and English units generally used in commerce. Old Spanish units and English units used in the interior and local trade. Metric system used officially and for exports. Spanish measures used largely by people in local trade and in the interior. Units of other countries employed in import trade. Metric system used in official work. Old Spanish measures used to large extent by people. English units also used in commerce.
Panama	450,000	Metric Spanish English	1853	1857 (government depts.) 1916 (Official)	
Ecuador	2,000,000	Metric Spanish English	1856	1866 (for govern- mental and de- partmental work)	
Peru	5,800,000	Metric Spanish English	1863	1869 (for official uses) 1916 (Lima and Cal- lao, for commer- cial houses)	

* Arranged according to date metric system was first introduced. For alphabetical arrangement see pp. 29-33 of present report.

TABLE V—Continued
PRESENT NATIONAL STATUS OF METRIC, ENGLISH AND OTHER SYSTEMS OF WEIGHTS AND MEASURES
(C) Other Countries—Cont'd

Name of Country	Population 1920	What Systems in Use	Date Metric System Made Optional	Date Metric System Made Compulsory for Special Uses	Comment
Bolivia	2,900,000	(a) Spanish Metric Spanish English	1870	<i>General Use</i> 1893 (for official work)	Metric system is official standard for governmental work and is used in large transactions. English units occasionally used, and people at large still cling to old Spanish rod system. Metric system in official use. Retail merchants still use pounds for weights and old Spanish measures for length. Metric system used in official work and by the people for legal transactions. Used generally by educated people. Old Spanish weights and measures still in use among illiterates and in the interior. System of country dealt with used in commerce. Metric system used in commerce with Europe, but English in commerce with North America. Metric system generally used for customs duties and public documents, but not by the native trades people and Indians, who use old Spanish units.
Costa Rica	460,000	Metric Spanish English	1885	1885 (for all uses)	
Salvador	1,300,000	Metric Spanish	1886	1886 (for govern- mental work) 1912 (for general use)	
Guatemala	2,200,000	Metric English Spanish	1894	1894 (for official work)	

Honduras	630,000	(a) <i>Spanish System in General Use</i> Metric Spanish English	1897	....	Metric system has not supplanted the older Spanish standards still in general use. English units also commonly used.
Greece	5,000,000	(b) <i>Other Natural Systems in General Use</i> Local Greek units Turkish Metric	1836	1920 ^a (for general use)	Metric system used only in official work. People in general use old Greek units in commerce and local trade. Old Turkish units occasionally used.
India	315,200,000	Local units mostly used Metric used only occasionally	1871	....	Use of metric system never popularized. Local units in general use.
Egypt	12,750,000	Metric English Local units chiefly used	1873 1892	1892 (Governmental departments only)	Metric system used officially and by engineers, architects and contractors. Most of wholesale and retail trade employ old Egyptian weights and measures. English units in use to small extent.
Turkey	8,000,000 ^a	Metric Turkish	1886	1889 (for cereals) 1891 (in Constantinople) 1915 (for official use)	Metric system largely used officially, but very little among the people. Compulsory metric legislation passed, but not enforced. Old Turkish units in general use.

^a Metric system made compulsory in 1920 and has not yet displaced the old units in general use.

^a Statesman's Year Book, *loc. cit.*, estimated population of the present empire.

TABLE VI
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918¹
South America²

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported ³
	1913	1918	1913	1918	1913	1918	
Argentina	409,554,669	482,724,083	14.72	33.86	31.06	24.99	Textiles Foodstuffs (sugar) Metal products Glassware & Crockery Lumber products Chemicals Oils Paper Machinery Building materials Vehicles Coal
Bolivia	22,138,447	13,334,000	7.38	30.9 ⁴	20.36	32.4	Leather products Textiles and clothing Foodstuffs (cattle) Hardware Wines and spirits Machinery Vehicles

Brazil	326,426,760	256,690,051	15.27	35.94	23.76	20.42	Textiles (dyeing and finishing) Chemicals Oils Coal Breadstuffs (flour) Metal products Machinery Leather products Paper Vehicles Lumber products Textiles Chemicals Metal products Food products Machinery Products of mining (coal) Products of agriculture Products of live stock Products of forestry Vehicles Paper
Chile	120,109,243	158,948,992	16.74	43.6	30.03	18.72	

¹ From "Statesman's Year Book," 1915, 1916, 1917 and 1920. When taken from other sources it is so indicated. In this table all conversions are made at par of exchange.
² Imports from the United States for 1918 into Chile, Cuba, Nicaragua, Panama, Salvador, San Domingo and Venezuela, are taken from the "Statistical Abstract of the United States," 1919, Table No. 448, pp. 826-7.
³ Products are arranged in order of importance (import values).
⁴ "Statistical Abstract of the United States," 1920, Table No. 454, p. 838.

TABLE VI—Continued
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT. IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
South America—Cont'd

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Colombia	26,231,753	21,417,048	28.27	56.72	21.63	26.93	Textiles (cotton goods) Food products Flour Petroleum Chemical Machinery Paper (1917) Textiles Food products Chemicals Machinery Hardware Vehicles Iron products
Ecuador	8,517,233	8,111,690	31.9*	57.11	23.66	23.30	

Guiana (British) ...	8,233,593	18,642,114	22.3	39.4	53.5	22.8	Foodstuffs Textiles Machinery Chemicals (fertilizer) Oils Coal Hardware Boots and shoes Lumber Textiles Food products Hardware Wines and spirits Drugs Machinery Chemicals (1917) Coal Textile bags Food products (flour) Lumber products Machinery Chemicals Vehicles Pipes Leather products Paper Oil products
Paraguay	7,892,635	5,007,477*	6.0*	13.37*	28.0	19.7	
Peru	29,591,451	47,166,849	31.3	54.29	25.55	16.14	

* "Statistical Abstract of the United States," 1915, Table No. 391, p. 716.
 * "Conventional Values" only (assigned by the customs tariff as the basis on which duties are collected). The actual or ascertained value of imports in 1918 is stated to be \$10,764,278.
 * "Statistical Abstract of the United States," 1913, Table No. 353, p. 688.
 * United States. Department of Commerce, Bureau of Foreign and Domestic Commerce. "Trade of the United States with the World," 1917-1918. Miscellaneous Series No. 78, part 2, p. 231.

TABLE VI—Continued
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
South America—Concluded

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Uruguay	51,127,200	66,955,933	14.9*	14.12	27.72	9.98	Foodstuffs Machinery Live stock Hardware Textiles Chemicals Vehicles Coal Leather products Paper Oil products Lumber products Textiles Drugs Foodstuffs Metal products Vehicles Paper Leather products Oil products Lumber products
Venezuela	20,513,010	16,440,209 (1917-18)	33.28	60.1	21.18	22.84	
Total South America	1,030,335,990	1,095,438,440	16.3	36.4	27.7	21.7	

* "Statistical Abstract of the United States," 1920, Table No. 288, pp. 398-425.

Mexico, Central America and West Indies²

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Costa Rica	8,686,448	3,735,595	51.44	57.9	14.85	7.87	Textiles (cotton goods and coffee bags) Cattle Food products Machinery Chemicals Vehicles Leather products Paper Oil products Drugs (1917) Foodstuffs Papers and tissues Machinery Metal Chemicals Textiles Leather products Oil products
Cuba	139,799,718	289,288,793	52.79	75.5	11.11	3.16	

TABLE VI—Continued
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
Mexico, Central America and West Indies—Cont'd

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent.)		Imports from United Kingdom (Per Cent.)		Products Imported
	1913	1918	1913	1918	1913	1918	
Guatemala	9,780,580	6,448,248	50.22	65.7*	16.40	21.2	Textiles (cotton) Metal products Foodstuffs Paper Machinery Vehicles Leather products Chemicals Oil products Lumber products Textiles Flour Lard Iron-works Machinery Oil products (Practically all im- ports from U. S. & U. K.)
Haiti	8,473,575	17,118,000** (1919)	59.4*	95.4** (1919)	6.63	6.2 (1919)	

Honduras	4,988,960	4,844,254	About 87.0	93.55	12.34	6.45	Textiles Foodstuffs Metal products Machinery Vehicles Chemicals Paper Leather products Lumber (Practically all from U. S. & U. K.) Vegetable products Textiles Mineral products Animal products Chemicals Vehicles Paper Leather products Coal Pipes and fittings Textiles Metal products Breadstuffs (flour) Machinery Leather products Coal Textiles Foodstuffs Breadstuffs Metal products
Mexico	95,145,352	80,000,897	49.69	85.83	13.23	5.96	
Nicaragua	5,608,445	5,763,770	57.96	78.1	20.56	11.8	
Panama	9,891,971 ²² (1912)	7,821,660 ²¹	54.83	81.2	24.53	8.29	

²² Cf. Table VII.

²¹ Exclusive of Canal materials.

TABLE VI—*Continued*
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
Mexico, Central America and West Indies—Concluded

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Panama— <i>Cont'd</i>							
23 38 Salvador	6,186,270	5,970,700	38.8 ¹	56.2	25.76	23.75	Oil products Machinery Chemicals Cement Lumber Textile (cottons) Hardware Flour Chemicals Drugs Textiles (cotton goods and fiber bags) Foodstuffs (rice) Metal products Leather products Chemicals Drugs Machinery
San Domingo	9,012,651	19,183,523	66.22	95.4	7.88	2.68	
<i>Total: Mexico, Central America, West Indies...</i>	297,574,020	440,175,440	52.7	78.8	12.8	4.6	

TABLE VI—Continued

IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM UNITED STATES AND UNITED KINGDOM, 1913 AND 1918

*European Metric Countries*²²

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Austria-Hungary .	687,364,380	893,215,000 ²³ (1917)	9.53	9.5 ²⁴ (1917)	6.41	....	(1913) Textiles (raw and manufactured) Coal Food products Hides and skins Machinery Prints and books (1913) Textiles Foodstuffs (wheat, coffee, corn, etc.) Hides Coal Chemicals Lumber products Metal products
Belgium	891,056,700	986,693,530 (1919)	9.07	38.6 (1919)	1.12	23.67 (1919)	

²² Statistics taken in most cases from "Statesman's Year Book," 1915, 1916, 1917 and 1920. Imports from the United States for 1913 into the following countries were taken from the "Statistical Abstract of the United States," 1919, p. 826, Bulgaria, Germany, Roumania and Serbia (1912). Imports from the United States into Austria-Hungary (1917), Belgium (1919), France (1919), Italy (1918), were also taken from the "Statistical Abstract of the United States," 1919, p. 826.

²³ Including Bosnia-Herzegovina, "Statistical Abstract of the United States," 1919, p. 826.

TABLE VI—*Continued*
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
*European Metric Countries*¹³—Cont'd

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Bulgaria	36,799,536	186,041,000 ⁴ (1919)	2.1	1.0 ⁴ (1919)	8.92	2.16 (1919)	(1913) Textiles Metal products Machinery Leather products (hides and skins) Cereals Cattle
Czecho-Slovakia ¹⁴	.....	117,941,061 (1919)	....	20.4 (1919)	....	1.12 ¹⁵ (First 6 months of 1919)	Food supplies (grain and fats) Raw material (cotton and wool) Coal
Denmark	228,922,621	255,150,000	10.17	4.0 ⁴	15.73	8.51	Cereals and foodstuffs Textiles Metal products and hardware Lumber products Colonial goods

Finland	90,292,604	98,094,240	Practically none	12.2	5.8	Foodstuffs (fish, cereals, sugar, coffee) Metal products Textiles (cotton) Machinery Chemicals Leather products Coal Foodstuffs (cereal) Metal products Textiles and raw products Arms and munitions Machinery Chemical products Petroleum Food products Raw minerals Chemicals Textiles (raw) Coal Metal products Machinery Food products (wheat, coffee, fish, etc.) Textiles and raw materials Coal Metal products Machinery Leather products
France	1,637,042,400	5,788,940,400 (1919)	10.5	13.06	12.36 (1919)	
Germany	2,723,231,988	.....	15.9	7.26	....	
Italy	707,183,460	3,117,918,614	14.2	16.08	16.43	

¹⁴ Included under Austria-Hungary prior to 1919. Import statistics for 1919 taken from "Statistical Abstract of the United States," 1920, explanatory notes, p. 844 (converted at par).

¹⁵ "Statesman's Year Book," 1920.

TABLE VI—*Continued*
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
Mexico, Central America and West Indies—Concluded

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Panama— <i>Cont'd</i>							
El Salvador	6,186,270	5,970,700	38.8 ¹	56.2	25.76	23.75	Oil products Machinery Chemicals Cement Lumber Textile (cottons) Hardware Flour Chemicals Drugs Textiles (cotton goods and fiber bags) Foodstuffs (rice) Metal products Leather products Chemicals Drugs Machinery
San Domingo	9,012,651	19,183,523	66.22	95.4	7.88	2.68	
<i>Total: Mexico, Central America, West Indies....</i>	297,574,020	440,175,440	52.7	78.8	12.8	4.6	

TABLE VI—*Continued*
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
*European Metric Countries*¹³

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Austria-Hungary	687,364,380	893,215,000 ¹⁴ (1917)	9.53	9.5 ¹⁵ (1917)	6.41	....	(1913) Textiles (raw and manufactured) Coal Food products Hides and skins Machinery Prints and books (1913) Textiles Foodstuffs (wheat, coffee, corn, etc.) Hides Coal Chemicals Lumber products Metal products
Belgium	891,056,700	986,693,530 (1919)	9.07	38.6 (1919)	1.12	23.67 (1919)	

¹³ Statistics taken in most cases from "Statesman's Year Book," 1915, 1916, 1917 and 1920. Imports from the United States for 1913 into the following countries were taken from the "Statistical Abstract of the United States," 1919, p. 826, Bulgaria, Roumania and Serbia (1912). Imports from the United States into Austria-Hungary (1917), Belgium (1919), France (1919), Italy (1918), were also taken from the "Statistical Abstract of the United States," 1919, p. 826.

¹⁴ Including Bosnia-Herzegovina, "Statistical Abstract of the United States," 1919, p. 826.

TABLE VI—*Continued*
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
European Metric Countries—Cont'd

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Jugo-Slavia	20,624,581 ¹⁴ (1912)	575,539,000 ¹⁵ (1919)	1.2 ¹⁶ (1912)	0.5 ¹⁷ (1919)	8.02 ¹⁸ (1912)	0.7 (1919)	(1912 ¹⁹) Textiles Hides Machinery Paper Metal products Salt Salt (from Turkey) Petroleum (from Russia) Corn Cottons Hardware Sugar, coffee and rice Metal products Coal Lumber products Textiles Cereals and flour Paper Fertilizers
Montenegro	1,653,746 (1910)	.....	None	Practically none	Practically none	Practically none	
Netherlands	1,586,790,000	224,271,178	11.3	4.26	8.7	12.86	

Norway	149,157,069	335,687,000 ⁴	6.19	15.9 ⁴	26.46	7.85	Vessels, carriages and machinery Minerals (raw and manufactured) Metal products Food products (raw and manufactured) Textiles Tallow, oils, tars, etc. Lumber products Paper Dyestuffs Raw cotton and wool Textiles Machinery Vehicles Metal products Cutlery and tools Leather products Leather (1916) Raw materials Food products Textiles Machinery Other manufactures (1915) Textiles Metal products Raw food products Machinery Lumber products Leather products Rubber
Poland	233,709,000 ¹² (1911)	.....	.....	.....	.....	.....	
Portugal	87,413,039	250,247,000 ¹⁰ (1919)	6.0	8.0 ¹⁰ (1919)	18.18	12.6 (1919)	
Roumania	114,698,449	98,797,000 ⁴ (1919)	5.4	0.9 ⁴	9.45	3.9 (1919)	

¹⁰ Imports for Serbia only.

¹² "Statistical Abstract of the United States," 1920, Table No. 434, explanatory notes, p. 844 (converted at par).
¹¹ Included under Austria-Hungary, Germany and Russia in 1911 and 1913.

TABLE VI—*Continued*
IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918
European Metric Countries—Cont'd

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1918	1913	1918	
Spain	229,286,373	118,555,214	14.03	58.2*	20.50	15.8	Food products (grain, sugar, animal prod- ucts) Textiles Machinery and vehicles Chemicals and drugs Stone, minerals and glassware Tobacco Metal products Lumber products Paper Coal Textiles Metal products and machinery Food products
Sweden	226,551,354	330,527,000*	9.13	6.7*	24.65	3.9	

TABLE VI—*Continued*

IMPORTS INTO LATIN-AMERICAN COUNTRIES AND EUROPEAN METRIC COUNTRIES AND PER CENT IMPORTED FROM
UNITED STATES AND UNITED KINGDOM, 1913 AND 1918

European Metric Countries—Concluded

Country	Total Imports (Value in Dollars)		Imports from United States (Per Cent)		Imports from United Kingdom (Per Cent)		Products Imported
	1913	1918	1913	1913	1918	1918	
Sweden— <i>Cont'd</i>							
Switzerland	373,212,284	466,916,530	6.07	22.3 ⁴ (1919)	5.80	10.22	Colonial wares Hides Lumber products Paper and pulp Food products Textiles Metal products and machinery Colonial produce Chemicals Timber Hides
Total: European Metric Countries	9,791,280,400	14,444,533,700	11.8	26.0	9.8	11.7	

TABLE VII

EXPORTS AND IMPORTS OF THE THREE GROUPS BY COUNTRIES; AND EXPORTS OF THE UNITED STATES TO EACH COUNTRY, AND PER CENT SUCH EXPORTS ARE OF THE TOTAL IMPORTS OF EACH COUNTRY—1919.^a

(A) *Metric Countries*

Name of Country	Total Exports 1919 (Dollars)	Total Imports 1919 (Dollars)	Exports of United States to each Country 1919 ^a (Dollars)	Per Cent of Total Imports of those Countries	Per Cent of Exports of United States
Argentina	994,881,000	632,820,000	155,899,000	24.6	2.0
Austria-Hungary	307,545,000 [*] (1917)	893,215,000 [*] (1917)	84,855,000 [*] (1917)	9.5	1.1
Belgium	441,801,000 [*]	977,749,000 [*]	377,882,000	38.8	4.8
Brazil	633,061,000	380,450,000	114,696,000	30.1	1.4
Bulgaria	106,585,000	186,041,000	1,788,000	1.0	0.02
Chile	278,567,000 (1918)	144,188,000 (1918)	66,404,000 (1918)	46.1	0.8
Colombia	36,721,000 (1918)	21,446,000 (1918)	10,546,000 (1918)	49.2	0.1
Congo (Belgian)	11,566,000 (1917)	10,467,000 (1917)	193,000 (1917)	1.8	0.0
Czecho-Slovakia	101,045,000 ^a	118,174,000 ^a	24,135,000 [*]	20.4	0.3
Denmark	196,818,000 [*]	675,025,000 [*]	163,957,000	24.3	2.1
Finland	168,501,000	483,540,000	21,814,000	4.5	0.3
France	1,681,641,000	5,747,254,000	893,360,000	15.5	11.4
Germany	2,393,566,000 ^a	7,705,488,000 ^a	92,761,000	...	1.2
Haiti	21,460,000 ^a	17,118,000 ^a	16,328,000	95.4	0.2
Italy	1,001,404,000	3,187,714,000	442,677,000	14.0	5.7
Jugo-Slavia	129,708,000 ¹	575,539,000	2,928,000 ¹	0.5	0.04
Latvia ^a .....	.....	.....	.....	.....	.....
Liechtenstein ² .....	.....	.....	.....	.....	.....
Luxemburg ²	198,345,000 (1918)	88,313,000 (1918)	76,220,000 ^a (1918)	85.8	1.0
Mexico .....	.....	.....	.....	.....	.....
Monaco ¹ .....	.....	.....	.....	.....	.....

Montenegro ¹	567,346,000	1,135,947,000	255,099,000	22.5	....
Netherlands	12,409,000	7,913,000	6,695,000	84.6	3.3
Nicaragua	209,599,000 ^m	692,444,000	135,135,000	19.5	0.09
Norway	14,298,000	15,282,000	894,000	5.9	1.7
Paraguay	122,729,000 [*]	107,774,000 [*]	70,552,000	65.5	0.01
Philippines	(140,908,000)	(233,709,000)	69,929,000 [*]		0.9
Poland ^a	(1911)	(1911)	(1920)	....	0.9
Portugal	119,454,000 [*]	250,247,000 [*]	19,962,000	8.0	0.3
Roumania	20,029,000	698,797,000	6,588,000	0.9	0.08
Spain	261,544,000	178,536,000	102,820,000	57.6	1.3
Sweden	425,904,000 ^a	679,103,000 ^a	133,069,000	19.6	1.7
Switzerland	636,531,000	681,943,000	76,146,000	11.2	1.0
Tunis	38,992,000	55,152,000	4,213,000 [*]	7.6	0.05
Uruguay	152,298,000	78,320,000	31,420,000	40.1	0.4
Venezuela	49,923,000	24,484,000	14,429,000	58.9	0.2
Total: Metric Countries	11,334,270,000	26,450,483,000	3,473,394,000	....	44.4

^a The statistics for the most part were taken from the "Statistical Abstract of the United States." (Department of Commerce), 1920, Table No. 454, p. 838. Where taken from other sources, the source is so designated. These statistics show the latest available figures and for the most part are taken from the Reports of the respective governments, foreign currencies having been converted at par.

^b "Statistical Abstract of the United States," 1920, Table No. 288, pp. 398-425.

^c "Statistical Abstract of the United States," 1919, Table No. 448, pp. 826-7. Bosnia-Herzegovina and Liechtenstein included in statistics of Austria-Hungary, 1917.

^d Export and import figures converted at par resulting in some discrepancy.

^e On the basis of imports from the United States, taken from explanatory notes on p. 844 (Statistical Abstract of the United States, 1920), Table No. 454.

^f United States, Bureau of Foreign and Domestic Commerce, data from monthly report of trade, December, 1920, subject to revision.

^g Department of Commerce, *Commerce Reports* No. 291, December 11, 1920. Exports reported as 32,376,000,000 marks and imports as 10,957,000,000 marks. Converted at par, resulting in an inflation of figures given.

^h United States, Bureau of Foreign and Domestic Commerce, data from official annual report.

ⁱ Export and import figures converted at par. It is stated that the export figures are somewhat incomplete. These figures include also those of Montenegro.

^j Included under the imports and exports of Austria-Hungary, 1917.

^k Included under the imports and exports of Germany.

^l The commerce of Monaco is small and unimportant.

^m Department of Commerce, *Commerce Reports* No. 119, May 23, 1921.

ⁿ The statistics for Poland for 1911 are taken from the "Statesman's Year Book," 1920. These figures are included in the statistics for Germany, Austria and Russia for 1911, and therefore will be excluded from the compilation. Recent statistics are not available.

^o Department of Commerce, *Commerce Reports* Supplement No. 14 b, November 3, 1920.

^p Including exports to Danzig.

^q United States, Bureau of Foreign and Domestic Commerce, data from January, 1920, monthly report, subject to revision.

TABLE VII

EXPORTS AND IMPORTS OF THE THREE GROUPS BY COUNTRIES; AND EXPORTS OF THE UNITED STATES TO EACH COUNTRY, AND PER CENT SUCH EXPORTS ARE OF THE TOTAL IMPORTS OF EACH COUNTRY—1919.^a

(A) *Metric Countries*

Name of Country	Total Exports 1919 (Dollars)	Total Imports 1919 (Dollars)	Exports of United States to each Country 1919 ^a (Dollars)	Per Cent of Total Imports of those Countries	Per Cent of Exports of United States
Argentina	994,881,000	632,820,000	155,899,000	24.6	2.0
Austria-Hungary	307,545,000 [*]	893,215,000 [*]	84,855,000 [*]	9.5	1.1
Belgium	441,801,000 [*]	977,749,000 [*]	377,882,000	38.8	4.8
Brazil	633,061,000	380,450,000	114,696,000	30.1	1.4
Bulgaria	106,585,000	186,041,000	1,788,000	1.0	0.02
Chile	278,567,000	144,188,000	66,404,000	46.1	0.8
Colombia	36,721,000	21,446,000	10,546,000	49.2	0.1
Congo (Belgian)	11,566,000	10,467,000	193,000	1.8	0.0
Czecho-Slovakia	101,045,000 ^a	118,174,000 ^a	24,135,000 [*]	20.4	0.3
Denmark	196,818,000 [*]	675,025,000 [*]	163,957,000 [*]	24.3	2.1
Finland	168,501,000	483,540,000	21,814,000	4.5	0.3
France	1,681,641,000	5,747,254,000	893,360,000	15.5	11.4
Germany	2,393,566,000 ^a	7,705,488,000 ^a	92,761,000	...	1.2
Haiti	21,460,000 ^a	17,118,000 ^a	16,328,000	95.4	0.2
Italy	1,001,404,000	3,187,714,000	442,677,000	14.0	5.7
Jugo-Slavia	129,708,000 ¹	575,539,000 ¹	2,928,000 ¹	0.5	0.04
Latvia ^a .....	.....	.....	.....	.....	.....
Liechtenstein ¹ .....	.....	.....	.....	.....	.....
Luxemburg ¹ .....	.....	.....	.....	.....	.....
Mexico	198,345,000	88,313,000	76,220,000 [*]	85.8	1.0
Monaco ¹ .....	.....	.....	.....	.....	.....

Montenegro ¹ .....	.....	1,135,947,000	.....	255,099,000	.....	3.3
Netherlands	567,346,000	7,913,000	.....	6,695,000	22.5	0.09
Nicaragua	12,409,000	692,444,000 ^m	.....	135,135,000	84.6	1.7
Norway	209,599,000	15,282,000	.....	894,000	5.9	0.01
Paraguay	14,298,000	107,774,000 [*]		70,552,000	65.5	0.9
Philippines	122,729,000 [*]	(233,709,000)	.....	69,929,000 ^p	.....	0.9
Poland ^a	(140,908,000)	(1911)	.....	(1920)	.....	0.3
Portugal	119,454,000 [*]	250,247,000 [*]		19,962,000	8.0	0.08
Roumania	20,029,000	698,797,000	.....	6,588,000	0.9	1.3
Spain	261,544,000	178,536,000	.....	102,820,000	57.6	1.7
Sweden	425,904,000 ^q	679,103,000 ^q	.....	133,069,000	19.6	1.0
Switzerland	636,531,000	681,943,000	.....	76,146,000	11.2	0.05
Tunis	38,992,000	55,152,000	.....	4,213,000 ^r	7.6	0.4
Uruguay	152,298,000	78,320,000	.....	31,420,000	40.1	0.2
Venezuela	49,923,000	24,484,000	.....	14,429,000	58.9	0.2
Total: Metric Countries	11,334,270,000	26,450,483,000	.....	3,473,394,000	.....	44.4

^a The statistics for the most part were taken from the "Statistical Abstract of the United States," (Department of Commerce), 1920, Table No. 454, p. 838. Where taken from other sources, the source is so designated. These statistics show the latest available figures and for the most part are taken from the Reports of the respective governments, foreign currencies having been converted at par.

^b "Statistical Abstract of the United States," 1920, Table No. 238, pp. 398-425.

^c "Statistical Abstract of the United States," 1919, Table No. 448, pp. 826-7. Bosnia-Herzegovina and Liechtenstein included in statistics of Austria-Hungary, 1917.

^d Export and import figures converted at par resulting in some discrepancy.

^e On the basis of imports from the United States, taken from explanatory notes on p. 844 (Statistical Abstract of the United States, 1920), Table No. 454.

^f United States, Bureau of Foreign and Domestic Commerce, data from monthly report of trade, December, 1920, subject to revision.

^g Department of Commerce, *Commerce Reports* No. 291, December 11, 1920. Exports reported as 32,376,000 marks and imports as 10,057,000,000 marks. Converted at par, resulting in an inflation of figures given.

^h United States, Bureau of Foreign and Domestic Commerce, data from official annual report.

ⁱ Export and import figures converted at par. It is stated that the export figures are somewhat incomplete. These figures include also those of Montenegro.

^j Included under the imports and exports of Austria-Hungary, 1917.

^k Included under the imports and exports of Germany.

^l The commerce of Monaco is small and unimportant.

^m Department of Commerce, *Commerce Reports* No. 119, May 23, 1921.

ⁿ The statistics for Poland for 1911 are taken from the "Statesman's Year Book," 1920. These figures are included in the statistics for Germany, Austria and Russia for 1911, and therefore will be excluded from the compilation. Recent statistics are not available.

^p Department of Commerce, *Commerce Reports* Supplement No. 14 b, November 3, 1920.

^q Including exports to Danzig.

^r United States, Bureau of Foreign and Domestic Commerce, data from January, 1920, monthly report, subject to revision.

TABLE VII—*Continued*
EXPORTS AND IMPORTS OF THE THREE GROUPS BY COUNTRIES; AND EXPORTS OF THE UNITED STATES TO EACH COUNTRY, AND PER CENT SUCH EXPORTS ARE OF THE TOTAL IMPORTS OF EACH COUNTRY—1919.^a
(B) *English Countries*

Name of Country	Total Exports 1919 (Dollars)	Total Imports 1919 (Dollars)	Exports of United States to each Country 1919 ^b (Dollars)	Per Cent of Total Imports of these Countries	Per Cent of Exports of United States
Australia	495,712,000	461,596,000	95,085,000	20.6	1.2
British Guiana	15,015,000 ^c	16,530,000 ^c	5,511,000	33.3	0.07
Canada	1,216,444,000 ^c	916,429,000 ^c	734,244,000	80.1	9.4
Liberia	1,112,000	1,411,000	100,000	7.1	0.0
New Zealand	252,435,000	147,493,000	28,172,000	19.1	0.4
Porto Rico	89,396,000 ^c	73,061,000 ^c	67,800,000 ^c	92.8	0.9
Russia	393,162,000 ^c	411,816,000 ^c	82,436,000	20.0	1.1
Santo Domingo	39,461,000	22,019,000	18,741,000	85.1	0.2
Strait Settlements	270,066,000 ^c	261,480,000 ^c	12,135,000	4.6	0.2
South Africa	234,235,000	227,328,000	44,042,000	19.4	0.6
United Kingdom	3,885,282,000 ^c	7,941,650,000 ^c	2,278,558,000	28.7	29.1
United States	7,661,385,000 ^c	3,831,345,000 ^c	.....	....	....
<i>Total: English Countries</i>	14,553,705,000	14,312,158,000	3,366,824,000	....	42.2

^a "Statesman's Year Book," 1920.

^b *Commerce Reports* No. 155, July 6, 1921. Exports and Imports through the ports of Archangel and Odessa. These figures are converted at par and are reported as probably incomplete and not wholly reliable, representing as they do statistics compiled from information secured from official Soviet sources.

^c *Commerce Reports* Supplement No. 59 b, December 28, 1920.

TABLE VII—Continued
EXPORTS AND IMPORTS OF THE THREE GROUPS BY COUNTRIES; AND EXPORTS OF THE UNITED STATES TO EACH COUNTRY, AND PER CENT SUCH EXPORTS ARE OF THE TOTAL IMPORTS OF EACH COUNTRY—1919.^a
(C) Other Countries

Name of Country	Total Exports 1919 (Dollars)	Total Imports 1919 (Dollars)	Exports of United States to each Country 1919 ^b (Dollars)	Per Cent of Total Imports of those Countries	Per Cent of Exports of United States
Abyssinia ^u	.....	.....	10,000	....	0.0
Afghanistan ^u	.....	.....	.....	....	....
Armenia ^v	.....	.....	.....	....	....
Bolivia	51,284,000 ^b	22,122,000 ^a	4,771,000	21.6	0.06
China	857,270,000	879,270,000	105,515,000	12.0	1.3
Costa Rica	17,749,000	7,518,000	4,921,000	65.5	0.06
Cuba	470,259,000	313,166,000	278,391,000	88.9	3.6
Ecuador	20,856,000	11,583,000	7,501,000	64.8	0.1
Egypt	388,909,000	243,069,000	15,076,000	6.2	0.2
Greece	140,221,000 ^c	310,407,000 ^c	42,799,000	13.8	0.5
Guatemala	22,419,000	11,231,000	8,392,000	74.7	0.1
Hedjaz ^v	.....	.....	.....	....	....
Honduras	5,999,000	6,931,000	6,500,000 ^a	93.8	0.08
India	776,394,000	584,403,000	67,506,000	12.3	0.9
Japan	1,028,821,000	1,074,843,000	366,364,000	34.1	4.7
Mesopotamia	35,751,000 ^c	59,702,000 ^c	.....	....	....
Morocco	83,840,000 (1918)	62,645,000 (1918)	982,000 (1918)	1.6	0.01
Nepal	15,491,000 ^a (1918)	7,405,000 ^a (1918)	.....	....	....

^u Statistics not available.

^v Included under the imports and exports of Turkey.

TABLE VII—*Concluded*

EXPORTS AND IMPORTS OF THE THREE GROUPS BY COUNTRIES; AND EXPORTS OF THE UNITED STATES TO EACH COUNTRY, AND PER CENT SUCH EXPORTS ARE OF THE TOTAL IMPORTS OF EACH COUNTRY—1919.^a

(C) *Other Countries—Concluded*

Name of Country	Total Exports 1919 (Dollars)	Total Imports 1919 (Dollars)	Exports of United States to each Country 1919 ^b (Dollars)	Per Cent of Total Imports of those Countries	Per Cent of Exports of United States
Oman	764,000 ^r (1918)	747,000 ^r (1918)	.....	....	....
Palestine	2,189,000 ^r	11,809,000 ^r	.....	....	....
Panama	3,757,000	11,407,000	9,359,000 ^w	82.1	0.1
Persia	40,421,000	70,501,000	909,000	1.3	0.01
Peru	130,906,000	59,390,000	26,945,000	45.4	0.3
Salvador	16,745,000	14,958,000	5,934,000	39.7	0.07
Siam	59,712,000 ^c	36,559,000 ^c	1,938,000	5.3	0.02
Syria ^y .....	.....	.....	.....	....	....
Tripoli	1,463,000 ^r (1918)	19,185,000 ^r (1918)	352,000 (1919)	1.8	0.0
Turkey	164,855,000 ^r	397,951,000 ^r	25,232,000	6.3	0.3
Total: Other Countries.	4,273,075,000	4,180,802,000	979,397,000		12.1

^w "Statistical Abstract of United States," 1920, Table No. 454, p. 838, on the basis of imports from the United States.
^x *Commerce Reports* Supplement No. 62 a, November 26, 1920. Imports and exports through Basorrah and Bagdad. These figures are reported as probably incomplete.
^y *Commerce Reports* No. 138, June 15, 1921, conversions at par.

TABLE VIII
IMPORTS AND EXPORTS OF JAPAN AND CHINA, 1913 AND 1918 ¹
(Per Cent Imported from and Exported to the Various Countries)

JAPAN				
	Imports		Exports	
	1913 Per cent	1918 Per cent	1913 Per cent	1918 Per cent
Metric Countries				
Austria-Hungary	0.6	....	0.2	....
Belgium	1.4	....	0.6	....
France	0.8	....	10.1	8.3
Germany	10.1	....	2.2	....
Holland .....	....	....	0.1	....
Italy	0.2	....	5.0	....
Philippines	1.1	1.2	1.1	1.3
Switzerland	0.3	....	....	....
Other Countries				
Australia	2.2	3.3	1.4	3.7
British America ²	0.3	....	0.9	1.7
China	9.0	19.0	25.9	21.0
French Indo-China	3.6	3.7	0.2	0.6
Egypt	1.1	0.6	0.2	1.7
Great Britain	18.1	4.4	5.5	8.4
Hawaii .....	....	....	0.9	....
Hong Kong	0.2	....	5.6	0.6
British India	25.6	18.1	5.0	11.8
Dutch India	5.5	3.3	0.9	4.2
Asiatic Russia .....	....	....	0.7	2.3
European Russia .....	....	....	0.8	....
Siam	0.8	....	0.2	....
St. Settlements	0.8	2.0	1.6	2.5
United States	18.1	42.1	30.9	31.0
Total, Japan	99.8	97.7	100.0	99.1

CHINA				
Metric Countries				
Belgium	2.9	....	1.8	....
France	1.0	....	11.3	7.0
Germany	5.2	....	4.7	....
Italy .....	....	....	2.3	2.2
Other Countries				
Hong Kong ³	31.5	30.5	32.5	26.8
India	8.9	1.5	1.7	1.4
Japan	21.9	45.0	18.2	37.4
Russia and Siberia	4.1	....	12.5	....
Singapore .....	....	1.9	....	1.4
United Kingdom	17.8	9.4	4.5	5.8
United States	6.5	11.0	10.4	17.6
Total, China	99.8	99.3	99.9	99.6

¹ The statistics for this table were compiled from the "Statesman's Year Book," 1915 and 1920.

² Bermuda, Canada, West Indies, etc.

³ Trade through Hong Kong, which is a treaty port, under control of Great Britain, according to available statistics, is chiefly with non-metric countries, colonies or dependencies.

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The bibliography here presented is not intended to be exhaustive but rather selective. It includes the principal works on the subject of weights and measures in general and upon the metric and English systems in particular. No attempt has been made to list articles which have appeared in magazines, trade journals or newspapers touching upon the subject of this report but a list of the principal periodicals in which articles have appeared is given.¹ The idea has been to list the principal works and to suggest to the reader other sources to which he may refer in case he desires to pursue the subject in greater detail.

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¹ No newspapers have been listed. It should be stated in this connection, however, that articles and editorials bearing on the relative merits of the English and metric systems and the question of the compulsory adoption of the latter in the United States have appeared in the past fifteen years in many of the city dailies. References to articles in these and other periodicals may be found in the periodical indexes of any good library.

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INDEX

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 Afghanistan: 17n, 29.
 Agriculture: effect of metric system on in metric countries, 48; relation to weights and measures, 68; use of weights and measures in, 49, 69-70, 148-150.
 American Geographical and Statistical Society, 41.
 Argentina: 17n, 18, 34, 84, 87, 90, 165; English measures in shipping, 72-73; measures used in agriculture, 67-70; metric system compulsory for all uses, 17.
 Armenia: 17n, 29.
 Articles of Confederation, provision for weights and measures in, 36.
 Astronomical instruments, use of weights and measures in, 60.
 Australia: 27; English system predominant, 16.
 Austria: 20, 35, 162; metric system compulsory for all uses, 17n; sea mile and ship ton used in, 73.
 Austria-Hungary: 22, 23, 107, 168.
 Automobiles: 177; manufacture of as related to weights and measures, 94.
 Belgium: 20, 34, 84, 93, 99, 107, 139, 167, 168; metric system compulsory for all uses, 17n.
 British Engineer's Association, 191.
 Binary fractions: mixture of with decimal fractions, 132-133.
 Biology, relation of metric system to, 56.
 Bolivia: 29; metric system compulsory for all uses, 17n; metric system in land transportation, 72.
 Bosnia-Herzegovina: 23, 24.
 Brazil: 20, 34, 80, 84, 88, 90, 104; measures used in coal trade, 71; metric system compulsory for all uses, 17n; metric units in land transportation, 72; mixture of systems used in land measurements, 63; old units used in agriculture, 68-70.
 British Guiana: 27; English system predominant, 16.
 Breckinridge, L. P., cited, 194.
 Bulgaria: 20-21, 35, 168; metric system compulsory for all uses, 17n.
 Bureau of Standards, 164.
 Bingham, Eugene C., cited, 56.
 Butterfield, Thos. E., cited, 167.
 C. G. S. system, used in electrical engineering, 147.
 Calculations, use of English and metric systems in, 127-131.
 Canada: 27, 96, 201; English system predominant, 16.
 Canners, use of weights and measures by, 87.
 Central America, 106-107.
 Change in systems: 47; considerations affecting, 47-48; industrial factors involved in; relation of to various fields, 48, 49, 51, 54; relation to science and engineering, 64-65; relation to agriculture, mining, transportation, trade, 77; to manufacturing, 100-101, 118; to buying public, 76,

- 77; to foreign trade, 118; to mechanical standards, 173-180; demand for in agriculture, mining, transportation, trade, 77; in Great Britain, 189, 191, 198; in U. S., 189-197; character of demand for, 194; opposition to in retail trade, 75, 196-198; experience of countries in making, 161-173; confusion due to, 161-173, 180; practicability of, 161; time involved in, 179-180; relation to mechanical standards, 173-180.
- Chemical manufacturers, attitude toward change in systems: 92, 93.
- Chemistry, use of metric system in, 56.
- Chile: 21, 34, 84, 88, 90, 163; metric system compulsory for all uses, 17n; metric system in land transportation, 72; measures used in agriculture, 68; miscellaneous nautical measures, 73; retention of old measures in retail trade, 75.
- China: 17, 30, 155, 158, 168.
- Civil engineering, relation of weights and measures to, 63.
- Clemenceau, M., cited, 203.
- Coal Association, National, cited, 71.
- Collins, J. V., cited, 142.
- Colombia: 21, 34, 81, 84, 90; metric system in general use, 17; metric system predominant, 17; metric units used in land transportation, 72.
- Compulsory change: attitude of engineers toward, 65; practicability of, 161.
- Compulsory use, of metric system in various countries, 16, 17.
- Confusion: 168-173; of English units, 154; through use of two systems, 165.
- Congo: 21, 22; metric system compulsory for all uses, 17n.
- Conjoint Board of Scientific Societies (Great Britain): 93; Report of, cited, 58.
- Cost of change: factors involved, 180, 181, 183, 184; opinions of manufacturers on, 185, 186.
- Costa Rica: 30, 34, 35; land records in metric measures, 64; metric system compulsory for all uses in, 17n; metric system only partially enforced in, 17; neither English nor metric system predominant in, 17, 18; use of Spanish measures in, 76.
- Cotton manufactures: use of metric system, in, 80; persistence of old units in, 99.
- Cotton Manufacturers, National Association of, attitude toward change, 81-82.
- Cotton fabrics, National Association of Finishers of, cited, 81, 82.
- Countries in which English system predominates, 27.
- Countries in which neither metric nor English system predominates, 18, 29.
- Cuba: 17, 30; practice in land measurements varied, 63, 168; miscellaneous measures in use in mining, 70-71.
- Czecho-Slovakia: 22; metric system compulsory for all uses, 17n.
- Dale, Samuel S., cited, 167, 193.
- Decimal Association (London), 191.
- Decimal fractions, mixture of with binary fractions, difficulty of using, 127-133.
- De Laval Separator Company, 151.
- Demand for change: estimates presented, 189-190; relation to question of change in measures in industry, 52; opinions of individuals and manufacturers favoring, 190, 191; in engineering profession to metric system, 65; character of demand for, 192-198.
- Denier-Aune*, world's silk standard, 153.
- Denmark: metric system compulsory for all uses, 17n, 22; old land measurements, 64; ship measurements exempted from metric law, 35, 74.
- Domestic trade, use of weights and measures in, 154.
- Drug Manufacturers' Association, American, 93.
- Duodecimal subdivisions, 132.
- Du Vernois, M. Prieur, 9.
- Ecuador: metric system compulsory for government use, 17n, 30.
- Egypt: 31, 168; metric system compulsory for government use, 17n.
- Electrical engineering: measures used in, 147; use of metric system in, 61, 62.
- Elgin Watch Company, use of metric system in, 59.

- Engineering: 56; relation to other industries, 61.
- English countries: 17, 27.
- English system: adaptability, 137-140; advantages and use in calculations, educational work, technical literature, 141-144; best present day example of natural system, 2; development of, 4, 5, 6; essential characteristics of, 6; units of, 8; present national status, 111; use in watchmaking, 58-59; confusion in units and measures, 209; convenience, 137-140; extensive use of English language in relation to spread of, 202-203; extent of use of compared with metric, 200-202; industry of U. S. based upon, 42-43; interrelation of units, 123-127; multiplication and division of units, 127-131; number and names of units, 133-135; possibility of becoming universal, 200; recommendations for simplifying, 210-211; status in Great Britain and United States, 209-210; screw threads made to, 62-63; simplicity of, 135-137; simplification of sought, 42; suggestions for improvement of, 210-211; summary of arguments for and against, 212-216; unified and standardized in U. S., 38; use in mechanical standards, 83-85; use in engineering, 146-148 use in mechanical drawing, 148.
- Exports: influence upon weights and measures of various countries, 103, 112.
- Federal Constitution *in re* weights and measures, 36.
- Finland: 22, 89, 168; metric system compulsory for all uses, 17n.
- Foot, 179; units of linear measures in other systems corresponding to, 7; as lumber measurement, 88; Greek, 4; Roman, 5, 9.
- Foreign trade: extension of metric system to, 206; use of weights and measures in, 155-160.
- Foundries, use of metric system in, 84.
- France: 22, 34, 37, 38, 84, 90, 93, 95, 99, 107, 139, 156, 160, 167-169, 180, 202, 210; metric legislation in, 11-12; metric measure approximating pound in, 75; metric system compulsory for all uses in, 17n; metric system used in electrical engineering in, 61; use of French *boisseau* (bushel) measure in grain measuring, 68; use of old units by trades people, 75; weights and measures used by doctors and druggists in, 58; weights and measures legislation, 167.
- Francis, Dr. J. M. (Parke Davis & Co.), cited, 57n.
- Gas Association, American, cited, 92.
- Gears, effect of change on, 178.
- Geodetic Survey, importation of standard scale from English by, 38.
- Germany: 22-23, 35, 80, 84, 93, 99, 106, 107, 139, 156, 160, 162, 166-167, 168, 174, 180, 203, 210; measures used in potash trade, 70; measures used in shipbuilding, 73; metric system compulsory for all uses, 17n; metric system used in electrical industry in, 61; *pfund*—equivalent of English pound in, 75.
- Goodyear Tire & Rubber Company, cited, 151.
- Great Britain: 29, 38, 80, 87, 93, 94, 96, 99, 100, 104, 106, 107, 108, 109, 110, 117, 155, 156, 157, 158, 159, 160, 180, 191, 200, 201, 202; chance of metric system becoming universal in, 207-211; English system predominant in, 15; uniformity of weights and measures in, 210.
- Greece: 31; metric system compulsory for all uses, 17; results of metric law not yet evident, 17; neither English nor metric predominant, 17, 169.
- Guatemala: 31, 107, 166; metric system compulsory for government uses, 17n.
- Haiti: 23, 107; metric system compulsory for all uses, 17n.
- Hedjaz: 17n, 31.
- Herschel, Sir John, cited, 126.
- Holland: 168; English tonnage measure excepted from metric law, 73.
- Honduras: 17, 31.
- Hungary: 23, 35; English nautical mile legal in, 74; land measurements exempt from metric law in, 63; metric system compulsory for all uses in, 17n.

- Humphreys, Alexander C., cited, 194.
- Hydraulic Society, 86.
- Imports: influence upon weights and measures in various countries, 104, 112.
- India: 17n, 31-32.
- Industrial Fields of U. S.: number of workers employed, value of production and exported products, 52-54; interest in change of measures, 52; needs as regards weights and measures, 50; difficulty and cost of changing measures in, 49.
- Ingalla, Walter Renton, cited, 193.
- Ingersoll Trenton Watch Company, use of weights and measures by, 60.
- Institute of Chemistry, Great Britain, attitude toward metric system, 56.
- International Bureau of Weights and Measures, 41.
- International weights and measures movements: London Exposition, 1851, 12; Vienna Coin Treaty, 1857, 12; Latin Union, 1865, 12; metric treaty, 1875, 13.
- Italy: 23, 34, 89, 106, 107, 139, 156, 168, 174; metric system compulsory for all uses in, 17n.
- Interests of smaller industrial groups contrasted with larger, 50.
- International Congress of Electricians, 61.
- Japan: 17, 32, 155, 158, 168; metric and English units used in land measurements, 63; miscellaneous measures used in mining, 71; use of English system in electrical industry, 61.
- Jefferson, Thomas, 36.
- Jugo-Slavia (Bosnia, Herzegovina and Serbia): 23-24; metric system compulsory for all uses, 17n.
- Kennelly, Arthur E., 174.
- Kunz, Dr. Geo. F. (Tiffany & Co.), cited, 58.
- Kent, William, cited, 194.
- Land Measurements: relation of measures to, 63; retention of old units in, illustrated, 64; exemption of in metric countries, 147; use of English system in, 146, 148.
- Latin America: 34, 108, 109, 110, 156, 157, 158; English screw threads used in, 62-63; *libra*—equivalent of English pound, 75, 163.
- Latvia: 24, 35; metric system compulsory for all uses, 17n.
- Legalization of system, Distinguished From Use or Adoption, 15.
- Liberia: 27; English system predominant, 16.
- Liechtenstein: 24; metric system predominant, 17.
- Liggett Company, Louis K., cited, 57.
- Ligne*, used in Swiss watchmaking industry, 59.
- Linear measures, classes of ancient units, of, 3, 4; similarity of in natural systems, 6.
- Lumber: Manufacturers' Association, National, cited, 90; use of inch in, 88, 179.
- Luxemburg: 24, 34; metric system compulsory for all uses, 17n.
- Machine products, 178.
- Machine Tool Builder's Association, National, 86.
- Madison, James, 38.
- Manufacturing: effect of change of systems upon, 117; effect of metric system on in metric countries, 48; extension of metric system to, 205, 206; fields outlined, 78; reasons for retention of old weights and measures in, 48-49; special phases of in relation to a change in systems, 97-99; use of weights and measures in, 150-154.
- Marsh, E. A. (Supt. Wal'tham Watch Co.), cited, 59.
- Measures of weight and capacity, relation to linear, 2-3.
- Mechanical drafting, use of measures in, 63.
- Mechanical engineering, application of weights and measures to, 62; attitude to metric system in, 63.
- Mechanical standards, relation of change in measures to, 173.
- Medicine: relation of metric system to, 56, 57.
- Mesopotamia: 17n, 32.
- Methods of subdivision: binary, 4, 8; decimal, 4, 8; duodecimal, 4, 6.

- Metric system:** adaptability, 137-140; advantages in calculation, 141, 142, 143; advantages in educational work, 142, 143, 144; advantages in technical literature, 143, 144, 170-171; as distinguished from other systems, 2; countries in which official standard, 2; origin and spread, II; early history in France, 9-10; determination and construction of units, 10; establishment in France, 11-12; essential characteristics of, 13-14; introduction into various countries, 12-13; units, relationship of, 13-14; present national status, III; as time saver, 142; comprehensibility, 135-6, 137, 141; compulsory use in various countries, 16, 17; convenience, 137, 138, 139, 140; convertibility of units of, 126-127; countries in which it predominates, 18; discussion of in U. S., 40-43; legislation, 41-42; extent of use as compared with English, 201-204; extent of use in metric countries, 48; compulsory use of opposed by A.S.M.E., 63; interrelation of units, 123-127; made permissive in U. S., 41; multiplication and division of units, 127-131; number and names of units, 133-135; opposition to in U. S., 42; possibility of becoming universal, 199-200; simplicity and convenience of, 135-137, 164; summary of arguments for and against, 212-216; use in engineering, 146-8; use in mechanical drawing, 148; use in science and similar fields as related to extension to other fields, 205, 207; use of in agriculture, 71; use of in countries where optional, where compulsory for government use only, where compulsory for all uses, 117; use in watchmaking, 58, 59; value and use in science, 48.
- Mexico:** 24, 34, 72, 83, 87, 89, 107, 168; measures used for smelter products, 71; metric system compulsory for all uses, 17n; metric system in land transportation, 73; old local measures used in agriculture, 68.
- Microscopy,** relation of metric system to, 56.
- Mile,** English, land and sea, 5.
- Miller,** Fred J., cited, 174.
- Millers' National Federation,** cited, 88.
- Mining:** size, relations, functions and importance of field of, 66, 70, 71; effect of metric system on in metric countries, 48; measures used in U. S., 71, in Cuba, 71, in Peru, 71, in Japan, 71, in South Africa, 71, in Mexico, 70-71, in Germany, 70, in Uruguay, 70, in Brazil, 70, in Spain, 70; reasons for retention of old weights and measures in, 48; use of weights and measures in, 148-150.
- Minute measurements:** industries using, 60, 65.
- Miscellaneous industries,** attitude toward change in system, 97.
- Monaco:** 24; metric system compulsory for all uses, 17n.
- Montenegro:** 24; metric system compulsory for all uses, 17n.
- Morocco:** 17n, 32.
- Mouton,** Gabriel, 9.
- Napoleon I.,** cited, 131.
- Nepal:** 17n, 32.
- Netherlands:** 24, 34, 107; metric system compulsory for all uses, 17n.
- New Zealand:** English system predominant, 16, 27-28.
- Nicaragua:** 24-25, 34; metric system compulsory for all uses, 17n.
- Norway:** 25, 35, 95, 168; local measures used in agriculture, 68; metric system compulsory for all uses, 17n.
- Oman:** 17n, 32.
- Optical instruments,** use of weights and measures in, 60.
- Opticians, Wholesale Association of American:** 60.
- Palestine:** 17n, 32.
- Panama:** 32; metric system compulsory for all uses, 17n.
- Paper and Pulp Association,** American, cited, 91.
- Paper Trade Association, National,** cited, 90-91.
- Paraguay:** 25, 34, 106; metric system compulsory for all uses, 17n.
- Persia:** 17n, 32.
- Persistence of old units in manufacturing,** reasons for, 99.
- Peru:** 32, 84, 90, 96; metric system compulsory for government

- uses, 17n; metric system in land transportation, 72; miscellaneous measures used in mining, 71.
- Pharmacy, relation of metric system to, 56-57.
- Philippines: 25; metric system compulsory for all uses, 17n.
- Physiology, relation of metric system to, 56.
- Poland: 25; metric system compulsory for all uses, 17n.
- Porto Rico: 28; English system predominant, 16.
- Portugal: 25-26, 34, 95, 168; metric system compulsory for all uses, 17n.
- Postal regulations, effect of change to metric system on, 188.
- Prefixes, metric, 14.
- Prescriptions: use of metric system in, 57, 58.
- Professional field, statistics of, 55.
- Primitive systems: foundation for linear measures of, 3-4; units of, 3, 4, 6.
- Raw products: relation of weights and measures to, 76, 97, 98.
- Redfield, William C., cited, 156.
- Retail trade: 207; field analyzed, 74, 75; use of weights and measures in, 74, 75; opposition of to metric system, 75; use of metric system in, in metric countries, 48; use of weights and measures in, 154-155.
- Retention of old units, reasons for, 114-118.
- Revenue laws, effect of change to metric system on, 188.
- Roumania: 26, 168; metric system compulsory for all uses, 17n.
- Royal College of Surgeons (Great Britain), approves metric system, 58.
- Royal Society of Medicine (Great Britain), endorsement of metric system, 57-58.
- Rubber: manufacture of as related to weights and measures, 95, 96, 97.
- Russia: 28, 155, 201; English system predominant, 16; metric system used by doctors and pharmacists, 57.
- Salvador: 33, 35, 107; metric system compulsory for all uses, 17n.
- San Domingo: 28, 108; English system predominant, 16.
- Science: size and importance of field of, 55-56; use of metric system in, 48, 55-56, 144-5; relation to change in weights and measures, 64; attitude toward metric system, 65.
- Screw threads, percentage made in English system, 64.
- Screw Thread Commission, National, 153.
- Seed Trade Association, American, cited, 70.
- Serbia: 23-24, 168.
- Siam: 33; metric system compulsory for government uses, 17n.
- Silk industry: 81; persistence of old units in, 99.
- South Africa: 28; English system predominant, 16; miscellaneous measures used in mining, 71.
- Spain: 26, 34, 81, 89, 95, 156, 168; measures used in coal trade, 70; metric system compulsory for all uses, 17n; metric terms and equivalents used in records, 63; sale of cereals by Spanish measure, 68.
- Standards: English made uniform throughout U. S., 40; metric established by Congress, 41.
- Standards, mechanical: 173; difficulty of altering, 49; relation to question of change in weights and measures, 50-51, 61; character of, 62; discarding of, 177; alterations necessary, 179; gradual change of, 175; cost of change in, 183-184.
- Straits Settlements: 29; English system predominant, 16.
- Sweden: 26, 95, 168; metric system compulsory for all uses, 17n.
- Switzerland: 26, 35, 139, 162, 168; metric system compulsory for all uses, 17n; retention of old units in local trade, 75; sale of agricultural products by old measures, 68; weights and measures used in watchmaking, 58.
- Syria: 17n, 33.
- Tariff laws, effect of change to metric system on, 188.
- Towne, Henry R.: cited, 38, 186, 210.
- Trade: affected by measures used in agriculture, mining and manufacturing, 66; functions of, 67; analysis of field, 74, 75; size and importance of, 67, 74; influence

- on uniformity of weights and measures, 50; influence on retention of old units, 50.
- Transportation: size and importance of field of, 67; relations to other fields, 67; functions of, 67, 71; connection with weights and measures, 71; land, analyzed, 72; use of weights and measures in, 148-150.
- Traveling and buying public, effect of change upon, 76-77.
- Trieste inch, 89.
- Tripoli: 17n, 33.
- Tunis: 26; metric system compulsory for all uses in, 17n.
- Turkey: 33, 166, 168; metric system compulsory for all uses, 17n.
- Tutton, Charles H., cited, 129.
- United Kingdom, see Great Britain.
- United States: 29, 78, 81, 87, 90, 92, 94, 95, 96, 97, 99, 100, 104, 106, 107, 108, 109, 110, 111, 112, 118, 156, 157, 158, 159, 160, 162, 164, 165, 180, 181, 201, 202, 205; chance of metric system becoming universal in, 207-212; English standards made uniform in, 40; English system predominant in, 16; English system unified and standardized, 38; history of weights and measures in, 36; international electrical units made obligatory in, 61; measures used in mining field, 71; metric system compulsory in Government medical departments, 17; opposition to metric system in, 42, 63, 65, 70, 71, 77, 82-83, 85-87, 90, 90-91, 92-3, 95, 97, 100, 192, 195, 196-8, 208, 216; present weights and measures situation, 42; uniformity of weights and measures in, 209; weights and measures used in watchmaking in, 58-59.
- United Typothetae of America, cited, 91.
- Uruguay: 26-27, 34, 88, 90, 104, 106; English nautical measures generally used, 73; measures used in agriculture, 68; measures used in stone trade, 70; metric system compulsory for all uses, 17n; metric system in land transportation, 72; old measures expressed in metric equivalents used in land measurements, 63.
- Venetian inch, 89.
- Venezuela: 27, 34, 84, 88, 90, 96, 165; equivalents of old measures used in retail trade, 75; metric system compulsory for all uses, 17n; metric system used in land transportation, 72; use of English units in nautical practice, 73.
- Waltham Watch Company, 59.
- Washington, George, 36-37.
- Watchmaking: weights and measures used in, 58, 59.
- Water transportation: field analyzed, 72; English nautical mile worldwide standard, 72, 73; connection of with weights and measures, 72; English ship ton in, 73.
- Wells, William C., cited, 163.
- West Indies, 106-107.
- Wholesale trade: analysis and importance of, 74; use of weights and measures in, 74.
- Wool industry, 80.
- Wool Manufacturers, National Association of: attitude toward change, 80, 82.
- World Trade Club, 189.
- Yard, adopted in United States, 38.

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